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EDITORIAL

THE TRUE ROLE OF THE CLINICIAN

Until the time when the germ theory of disease was enunciated and the origin of certain infectious diseases was explained, physicians groped in the darkness of empiricism. All their attempts to repel disease were bent towards the fortuitous discovery of remedies to stay or resolve abnormal conditions, which were established, so well, that their existence was made manifest by obvious clinical signs and symptoms. The art of diagnosis, sometimes it was founded on intuition only, was based on the recognition of a picture which had been exhibited or recorded on some previous occasion. Much depended upon the physician's powers of observation and the acuity of his visual, tactile and olfactory senses. One must remember that, up to the end of the eighteenth century, most doctors were not informed too well with regard to the anatomy of the body, other than that of the skeletal framework, and their knowledge of its physiological functions, other than those which are most obvious and crude, was founded on theory and developed by speculative conjecture.

Auscultation can be of little value if the listener is ignorant of the origin, and the identity and meaning of the sounds which accost his ear. The old time physicians and farriers were at great disadvantage, for their investigations were limited to a survey of the exterior and the recognition of simple physical signs and symptoms. Now the skin is said to be a mirror which reflects the state of health and the general condition of the body. A critical examination of the integument can tell us much, indeed in some instances an acute observer need look no further. In spite of the disadvantages under which medical men worked in these times, when judged by modern standards, a considerable amount of valuable clinical knowledge was accumulated and by the method of trial and error a number of efficient remedies were evolved. Some of the latter have stood up to the tests of more enlightened times. Probably the best example is exemplified in the use of Peruvian bark, which was found to be almost a specific remedy for the serious febrile disease called ague. The alkaloid quinine which is derived from this bark is still recognised as an effective remedy for this disease which we now call

Malaria. This discovery was made before it was known that the bark contained this essential principle, or that the distressing miasmatic fever was caused by a protozoan parasite which invaded the red blood cells and was transmitted by a mosquito of the genus Anopheles. Similarly the beneficial effects of vaccination against smallpox was discovered and the operation was practised in Turkey and in England long before a causal virus was identified.

As anatomical and physiological knowledge concerning the normal body expanded, the door was opened for the study of that which was abnormal and the discipline of pathology was born. Laennec with his stethoscope enabled the ear to pioneer amongst the sounds which arise within the chest and in the circulatory system and the introduction of the clinical thermometer enabled one to assess the general metabolic response of the body. Good physicians welcomed these aids, but they acknowledged them as ancillary agents only and recognised that diagnosis and treatment still depended in greatest measure upon the physician's powers of observation, his ability to blend present findings with those garnered from the store of experience and the sagacious exercise of the virtues of common sense and good judgment.

A doctor of those days was like a detective who, having discovered some cogent clues, cannot proceed to a final and positive conclusion and make an arrest because of the absence of a motive. Taking this simile of outlook a little further and with regard to the problems confronting a physician, the discovery that infectious diseases were due to the presence and activity within the animal body of micro-organisms supplied a motive for disease. If the cause or motive can be disclosed the investigation is complete. The germ doctrine was not accepted wholeheartedly by all physicians. Revolutionary ideas are received with some reserve by medical men. This can be a good attribute, it may be a bad one. The best way to ensure the initial rejection of any medical discovery or new form of treatment is to claim one hundred per cent. success.

It may be that those who supported the germ theory of disease were too enthusiastic and their claims were too extravagant for their more conservative colleagues to accept. In excuse for those who were reticent one must recognise that, at that time, most of the practising physicians were not proficient in the use of a microscope, probably they had never seen a micro-organism and such things were beyond their comprehension. Gradually the opposition of the " backwoodsmen " broke down and the idea gained credence that all diseases might be of germ origin. This conception went too far, but the golden age of bacteriology was born and young men flocked to its banner for, if a disease was initiated by a germ all one had to do was to isolate a particular offending agent and then bask in the glory of great achievement. This attitude did harm to the new discipline and it led also to some disparagement of the clinicians who had served so long and well, in their crude way, at the bedside, in the stable and in the byre, noting signs and symptoms and assessing their value.

Later on, the introduction of X-rays and the development of biochemistry, chemotherapy and haematology etc. amplified this trend. The new innovations dimmed some of the pristine glamour of the great discipline of Bacteriology which, after a period of epoch making discoveries, had settled on to more difficult times. Fortunately there are signs that the wheel of change has almost made a complete turn. The various ancillary disciplines which have been in the van of progress are now recognised as spokes and felloes in the wheel which turns the rudder of medical science.

The hand which rules the wheel is that of the clinician who is in personal contact with the stricken patient. The clinician is the man who is able to take stock of the whole situation and bear the full responsibility. He is the man who has to exercise judgment on the signs and symptoms displayed and decide which ancillary services are required and when and how they shall be used.

CALCIUM GOUT (KALKGICHT) AND CALCINOSIS CIRCUMSCRIPTA IN DOGS

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Granulomatous lesions have been examined from 32 dogs in which calcium salts were present as chalky-white irregular masses embedded in fibrous tissue. The lesions, chiefly affecting the subcutaneous tissue, are of the kind described by Kunze (1926) on the one hand as " Kalkgicht " (calcium gout), and by Thompson, Sullivan and Pedersen (1959) on the other as ' calcinosis circumscripta '. Pertinent details about the affected dogs are given in Table I.

Of the 32 dogs, 19 were Alsatians, and all but two of the 30 dogs of named breed were of large type. Eighteen of the dogs were male (including 11 Alsatians) and 10 were female (including 6 Alsatians)—the sex of four was not recorded. Twenty-three of the 32 dogs were two years of age or less, 15 of them being under one year. The lesions were exhibited by two older dogs (2 and 3½ years old) at the ages of 3 and 6 months respectively. In 25 dogs the lesions were on the limbs (hock 10, foot 7, elbow 5). Other sites recorded were: " front of shoulder "; " skin "; attached to right ischium; in the region of the 4th cervical vertebra; " subcutaneous ". The commonest site of the lesions in the Alsatians was the hock. This site was not mentioned specifically in any of the other dogs. Only two of the lesions were not related to skin and subcutaneous tissue; these affected the labial mucosa and the subepithelial tissue of the tongue respectively.

The lesions varied in size from 1 to 8 cm. in diameter. Most of them were between 1½ and 3 cm. They formed bulging masses which were mainly in the subcutis, but they tended to spread to the dermis. In 4 dogs they had ulcerated through the overlying skin, to discharge a milky-white material. The lesions (except in case 30) were all specimens obtained at surgical operations, and sometimes they were rather difficult to remove completely from the underlying tissues around tendon or bone, particularly so when they were on the hind limbs.

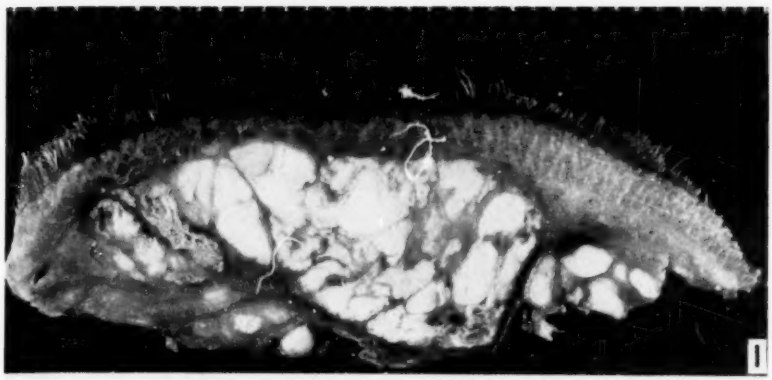
The cut surface of the lesions (Figs. 1 and 2) showed a characteristic appearance. There were irregular areas of a chalk-white coloured material embedded in a grey-white fibrous tissue. In most cases the areas were of a rather soft consistency. The relative amounts of white material and fibrous tissue varied, the former often predominating. These white areas were from one or two to several mm. across.

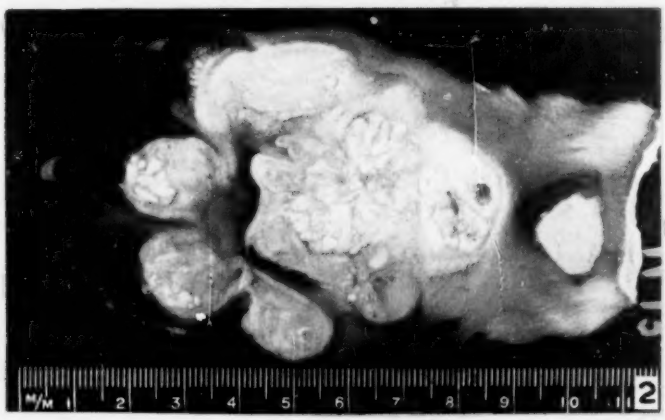
In section (H. and E.) (Fig. 3), a number of irregular masses can be seen. They are composed of fine (1-3 μ) and coarse (up to 100 μ) granular material, which gives a more or less basophil staining reaction. These masses are surrounded by a zone, which varies in its width, of cells, including lymphocytes, plasma cells, endothelioid cells and multinucleate cells of Langhans or foreign body giant-cell type. Some of the giant cells are very large: one (case 4) is 180 μ, and another (case 13) is 210 μ long. In some instances the number of giant cells, and their close approximation to each other, make a picture which almost suggests the presence of a stratified epithelium

TABLE I

Showing age, breed and sex of 32 dogs with "calcium gout", and the site and size of the lesions.

Case No.	*Breed*	*Age*	*Sex*	*Site*	*Size (cm.)*	*Remarks*
1	Alsatian	6 months	Male	Hock	4 x 1½	Dermal Swelling
2	„	8 „	Male	In front of shoulder	8 x 5 x 2	Not attached to skin
3	„	9 „	Male	Below right hock	1½ x 1	
4	„	10 „	Male	Subcutaneous		
5	„	10 „	Male	Hock		
6	„	11 „	Male	Right hock, anterior		First seen at 6 months of age
7	„	11 „	Male	Outer aspect left hock	3	Milky-white discharge from several points
8	„	18 „	Male	Right hock, lateral aspect		
9	„	18 „	Male	Right hock		
10	„	4 years	Male	Digit	1	Bulging pyramidal lesion, outside toe
11	„	6 „	Male	Hock	3½ x 2½ x 2	Skin and subcutis. No recurrence 2 years later.
12	„	6 months	Female	Leg		Attached to tendons
13	„	8 „	Female	Right elbow, posterior	3 x 2 x 2	Doubled in size since 6 months; ulcerating, milky discharge
14	„	10 „	Female	Hock, and metatarsus (2)	2 x 1½ 1½ x 1	
15	„	11 „	Female	Left hock		
16	„	18 „	Female	Side of foot	1½ x 1½ x 1	In subcutis
17	„	3½ years	Female	Ischium and subcutis	4½ x 3 x 3	Present at 6 months of age
18	„	5 months	?	4th cervical vertebral region	3.8 x 2.5	
19	„	?	?	Interdigital		
20	Boxer	2 years	Female	Leg, next pad	2 x 2 x 1	Subcutis, with dherent skin
21	Bull Terrier	1 „	Female	Elbow	2 x 1.5 x 1.5	Present "since birth"
22	Dachshund	"puppy"	Male	Region of hind dew-claw	3½ x 1	Partly ulcerated
23	Great Dane	2 years	Female	Above a lateral hind digit	3 x 2	Present since 3 months of age
24	Greyhound	6 „	Male	Right hind digit	3.2 x 1.2	Subcutaneous
25	Labrador	1 „	Male	Elbow	3 x 4	
26	„	1½ „	?	Side of tongue		
27	„	4-5 „	?	Elbow		Slow growth over long period
28	„	5-7 „	Male	"Skin"		
29	Mongrel	10 months	Female	Right upper labial mucosa		Present 2 months
30	„	9 years	Male	Feet, esp. r.f. and l.h.		Chronic contracted kidneys
31	Norwich Staghound	2 „	Male	Elbow	3 x 3 x 2½	Subcutaneous. No recurrence 4 years later
32	Sealyham	9 months	Male	Left hind foot, by pad		





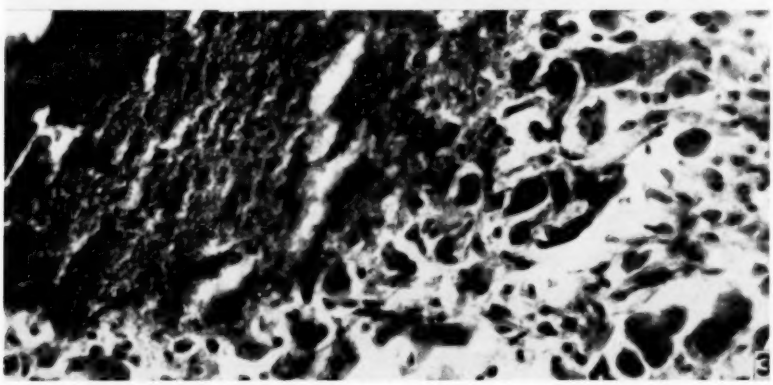


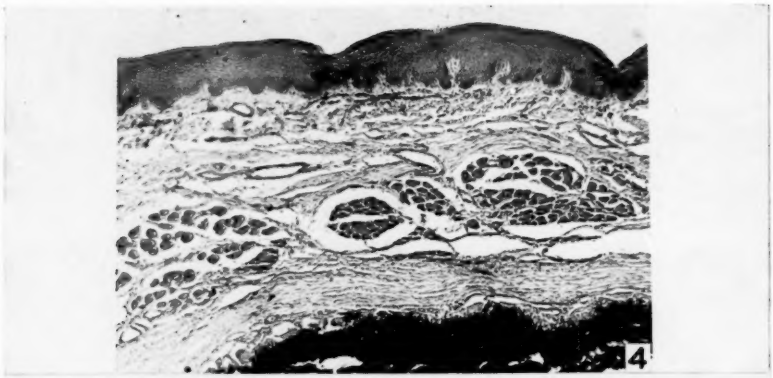
FIG. 1. Subcutaneous lesion of calcium gout from hock of 9 month old male Alsatian dog, showing white irregular areas in the subcutaneous granuloma. (Scale in mm.)

FIG. 2. Lesions of calcium gout in the digital pads of a 9-year-old male mongrel dog (case 30) (Scale in cm.)

FIG. 3. Section of subcutaneous lesion of calcium gout of the shoulder region of an 8-month-old male Alsatian dog (case 2), showing the basophil granular material sounded by and appearing to incorporate a peripheral cellular zone. H & E x340.

(Article by Cotchin, page 3)

PLATE 2



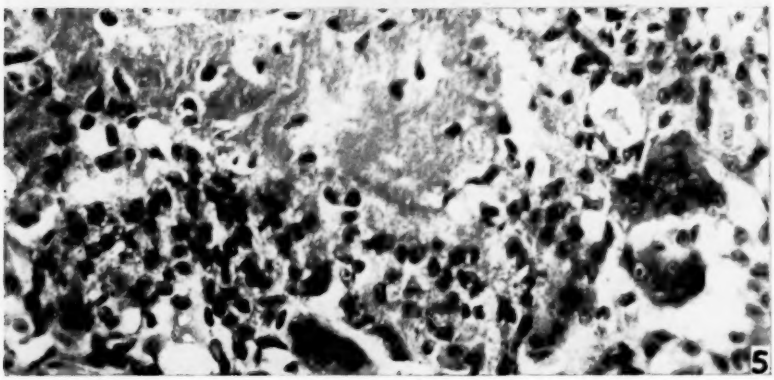


FIG. 4

Lesion of calcium gout of the tongue of a 1½-year-old Labrador dog (case 26), prepared by von Kossa's silver nitrate method to show calcified material (below), separated by cellular zone and fibrous capsule from the tongue muscle and mucosa (above). x57.

FIG. 5

Section of calcium gout lesion of tongue (same case as Fig. 4), showing PAS-positive material (appearing light grey in section), surrounded by a cellular zone, including giant cells. Some of the cells appear to have become embedded in the PAS-positive material. x340.

(Article by Cotchin, page 3)

around the granular centres. Some of the giant cells and endothelioid cells lose their clear outline and, becoming finely granular, appear to be incorporated in the granular centres, where scattered nuclei may be seen. In this cellular zone, one or more capillary blood vessels may be prominent, and in some instances the giant and endothelioid cells appear to be closely applied to the outside of these vessels. Occasionally haemorrhage from these vessels has occurred into the cellular or the granular zone.

The granular centres and cellular borders are embedded in a variable amount of more or less dense fibrous tissue; in a few instances this is very cellular, with mitotic figures in some cells. The fibrous tissue is not arranged as a capsule to the granular and cellular areas in every instance. In a few cases these areas are not surrounded by a capsule.

Chemical analysis demonstrates that the white material consists, in part, of calcium phosphate. It stains black or dark brown with von Kossa's silver nitrate method (fig. 4); the large granules sometimes do not take up much silver. Droplets of fat are present (Scharlach R) in the endothelioid and giant cells, and in one case tested a moderate alkaline phosphatase reaction is present around the granular areas. Some amorphous granules appear to be dislocated from the centres into surrounding tissue, with little local reaction. The granular amorphous material is also PAS positive (fig. 5), sometimes quite strongly so.

Some lesions require special mention:

A nine-year-old male mongrel (case 30), of moderately large size, had for two months shown swelling of its feet, circumscribed areas containing chalky-white material being seen chiefly in its pads. The animal was anaemic, showed a cardiac disorder suggesting mitral stenosis, and had proteinuria. It was destroyed, and the autopsy (the only one made in this series) showed, besides the foot lesions (which chiefly affected the right fore- and left hind- feet), a very thickened mitral valve, and a marked chronic contraction of the kidneys. Histologically, the lesions of the pads are similar to those in the other cases.

A 3½-year-old Alsatian bitch (case 17) had shown a lesion, present since the age of six months, attached to the right ischium. On removal, this measured 4½ x 3 x 3 cm.; the upper part of the mass was covered by skin, the lower half consisted of rather soft bone. In section, bone is seen to be contiguous with amorphous granular deposits. Ossification is also seen, on histological examination, in the lesion of the right side of the tongue of a 1½-year-old Labrador (case 26). This lesion shows also some giant-cells derived from striped muscle.

Some chondrification is seen next to a granular focus in the hock lesion of a 6-month-old male Alsatian (case 1), and there is a basophil myxomatous appearance of the ground substance of the fibrous tissue in 5 lesions (cases 8, 6, 16, 21, 25).

In one lesion, some areas are present which may possibly be very early stages in the development of the granular foci. They consist of capillary vessels, around which are a few mononuclear cells, which may have a lot of cytoplasm and stain faintly blue in H.E. sections. These foci are devoid of granular material.

Discussion

" Kalkgicht " was a term borrowed from human medicine (Schmidt, 1913) by Kunze (1926) and applied to lesions affecting the connective tissue of the pads of the feet of a 5-year-old Alsatian bitch. These were white masses of soft cheezy appearance divided up into irregularly-shaped areas by connective tissue bands. When the bitch was destroyed 8 weeks after the lesions were first noted, autopsy showed well-developed subcutaneous and retroperitoneal fat deposits, cystic ovaries, and also (as in our case 30) markedly contracted kidneys. Kunze referred to 8 clinically similar cases seen in the previous 5 years. He showed that the chalky-white material in the lesions contained calcium phosphate and carbonate, and described the bordering cellular zone, including giant cells, and the fibrous capsule. Kunze produced lesions with a " striking similarity " to spontaneous ones by injecting a saline suspension of a mixture of calcium phosphate and calcium carbonate intramuscularly and subcutaneously into a dog, supporting the view that the tissue changes in calcium gout were the result of the deposition of calcium salts.

Further cases of calcium gout were reported by Kretzschmar (1955, 1956). In two dogs it was in association with chronic interstitial nephritis, and he mentioned 4 operation cases seen in 4 years. Nieberle (1949) stated that the condition was not rare in dogs in Leipzig.

Under the heading " calcinosis circumscripta ", Smith and Jones (1957, p.643) wrote that " circumscribed masses of calcium salts are sometimes recognised in the dermis of the dog. The lesion appears as a mass 1 to 10 cm. in diameter containing a cluster of chalky-white granular foci separated by thin strands of connective tissue. The entire nodule thickens the dermis and elevates the epidermis. The cut surface reveals its chalky appearance and gritty consistency. Microscopically, the lesion is seen to be composed of spherical masses of finely particulate blue-staining granules of calcium salts. The masses are surrounded by granulation tissue containing, in some areas, large numbers of foreign body giant cells ". Broadly speaking, this description would apply to the lesions which are noted in this record, except that our lesions are better described as lying in the subcutis rather than in the dermis (although that may be involved too), and that the chalky-white deposits are not often actually very gritty to the touch or to the knife. Smith and Jones do not refer to Kunze's paper, and apparently they do not recognize any similarity between the lesions they refer to and those of calcium gout.

The more recent report by Thompson *et al.* (1959) describes cases of " calcinosis circumscripta " in man (5 cases), dog (8 cases) and a monkey. They write: " Although a great deal of work has been done on calcinosis as it affects man and laboratory animals, Smith and Jones are the only authors who discuss its application to veterinary medicine ". It seems that these authors were unaware of Kunze's paper, or perhaps do not consider calcium gout and calcinosis circumscripta to be similar or identical conditions. Their cases were taken from the files of the Armed Forces Institute of Pathology, and the eight cases in dogs are listed in Table II.

It will be seen that four of their 8 cases were in young Alsatians, and two others at least were in large dogs. The lesions they described are closely similar to those that we have seen.

The cause of the lesions described here is not known, although both Kunze and Kretzschmar have reported cases in which the lesions of Kalkgicht occurred in association with " chronic interstitial nephritis ". Kunze in fact referred to a " Kalkdiathesis "; he also reported that the lesions in the thigh of one of his dogs developed at the site of injection of a phosphate-containing drug. Kretzschmar referred to a possible relationship to disturbed calcium metabolism, with parathyroid hyperplasia and osteodystrophia fibrosa: Nieberle (1949) however stated that the role of nephritis was not yet clarified, and referred to a possible primary disturbance of calcium metabolism. The possibility that the lesion is an example of metastatic calcification

TABLE II

Showing details of 8 dogs with " calcinosis circumscripta " reported by Thompson et al. (1959)

Case No.	*Breed*	*Age*	*Sex*	*Site*	*Size*
7	Alsatian	2 years	?	Left tarsal region	2.2 x 1.8 x 1.1
8	Alsatian	6 months	M	Distal end, medial surface, 1st metatarsal	3 x 3 x 1.5
9	Alsatian	18 months	F	Left elbow, subcutaneous	2.4 x 2 x 1
10	Large, mixed breed	10 years	F	Rt. elbow (2 tumours)	each about 3 cm. diameter
11	?	?	F	Subcutaneous, thoracic region	4 x 2.5 x 1 cm.
12	?	?	M	Foot (three subcutaneous masses)	each 1 to 1.5 cm. diameter
13	Labrador	1 year	?	Rt. hock, subcutaneous	2 x 2 x 1 cm.
14	Alsatian	10 months	F	Subcutaneous, by rt. 5th metatarsal	3.5 x 3.5 x 2 cm.

has been raised: in fact, in 3 of our cases, the dogs—young Alsatians—had been given high doses of vitamin D. However, the pattern of experimental metastatic calcification in dogs (Mulligan and Stricker, 1948) is quite different from calcium gout.

The pathogenesis of the lesions is still not clear. Kretzschmar (1956) described, in a foot lesion, calcification of muscle fibres in the pads, with a histiocytic and fibroblastic reaction. Thompson *et al.*, who made an extensive histochemical study of the lesions, described the centres of the granulomatous foci as " calcified necrotic tissue " but did not state categorically what tissue was necrotic. Both Kunze and Thompson *et al.* refer to mineralization of cells in the bordering zone. We have noted this in our own cases. This apparent incorporation of degenerating cells into the granular centres is not yet explained.

Thompson *et al.* felt that " noxious influences " such as prolonged and repeated traumatism of tissue were the most probable cause of the lesions. The lesions were thought to be the result of tissue damage at points of pressure: the initial change was apparently a local cellular necrosis (it is not stated which particular cells were involved), the inflammatory reaction appearing to be a response to the presence of necrotic tissue. Thompson *et al.* concluded that the lesions of calcinosis circumscripta were little different from " other relatively avascular foreign-body granulomatous lesions of long standing which have undergone mineralization of their necrotic centres ".

There are some points in favour of this view, for example the situation of the lesions on the limbs and their occurrence in heavy dogs. Perhaps the tissue of young dogs is more susceptible to damage, and perhaps Alsatians are more susceptible than

some other breeds. What is not clear is the way in which the lesions develop. There is no clear evidence of fat necrosis, and the possibility that some tissue disorder, structural or metabolic, may be the underlying cause cannot be dismissed. Kunze (1926) referred to the presence of a protein-rich material in the white areas, and Thompson *et al.* have also reported the presence of PAS—positive material in the calcified zones, suggesting that the mineral material is suspended in a mucinous matrix. The presence of a mucopolysaccharide material at the site of calcium deposition in human cases of calcinosis is also reported by Levine, Rubin, Follis and Howard (1949), who compare this with similar reactions at sites of normal calcification of bone or cartilage.

Since lesions of calcium gout are seen particularly in young Alsatians, the search for early lesions, which might help elucidate the pathogenesis, may be facilitated.

From the practical point of view, it appears that surgical removal of lesions, where possible, may be carried out successfully. If the lesions occur in older dogs, and particularly if they affect the feet, the possibility of a concurrent kidney lesion should be investigated. It may be that the majority of lesions of this kind will be found in young dogs, and usually for these there is no evidence of an association with nephritis.

Calcium gout and calcinosis circumscripta, as described in the literature and in the instances recorded in this paper, are closely similar conditions pathologically, if not identical aetiologically. For the time being the term " calcium gout " would seem to be a suitable one to apply to all cases, with the qualifying phrase " associated with nephritis " in appropriate cases.

Summary

Granulomatous lesions have been examined from 32 dogs, consisting of chalky-white masses of calcium salts embedded in fibrous tissue. The lesions occurred particularly in " heavy " dogs (19 were in Alsatians), and chiefly in young dogs (23 in dogs 2 years of age or less). One dog, aged 9, showed chronic interstitial nephritis.

The lesions resemble those previously reported as " Kalkgicht " (calcium gout) and as " calcinosis circumscripta ", and the term " calcium gout " is considered a suitable one for designating the lesions, wherever they occur. The cause and pathogenesis of the lesions are still unknown.

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NOTES ON SOME ANTHELMINTIC DOSING TRIALS ON SCOTTISH BLACKFACE HOGGS WINTERED ON IN-BYE FIELDS*

By

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Introduction

In Scotland there are three main methods of " wintering " hill Blackface and Cheviot hoggs†—on the hill, on the fields of the hill farm (usually referred to as the " in-bye " fields) and on low ground farms. Those wintered off the hill are nearly always put back to the hill early in April.

Several preliminary anthelmintic drenching trials have been made on Blackface and Cheviot hoggs wintered on the hill; they have been described in an earlier paper (Parnell, *et al.* 1955b) and resulted in increases of body and fleece weights.

When hoggs are sent away to " wintering " it is usual for them to be put on to worm-free, or almost worm-free, pastures that have been without sheep on them for five or six months; it is, therefore, a matter of common sense that the hoggs should be as worm-free as possible when they are taken to the winterings. Trial 9c, in practice, was comparable to the hoggs being sent away for wintering.

This paper describes some preliminary anthelmintic drenching trials on Scottish Blackface hoggs wintered on in-bye fields. When hoggs are wintered in this way they almost inevitably have to graze fields which have been used by large numbers of sheep during the summer and early autumn, although perhaps only for short intervals, at gatherings (musterings) and before sales, and by the rams. It follows, therefore, that hoggs wintered on in-bye fields tend to be subject to reinfestation.

Less is known about the levels and succession of the different species of helminths in hoggs on in-bye fields than is known about the infestations in hoggs wintered on the hill; however, the worm egg counts of the control undrenched hoggs in these trials suggest that the pattern is much the same as that of hill hoggs. There were falls in the worm egg counts following the autumn rise, and there were increased worm egg counts in late winter, lasting into the spring, which is similar to the pattern of hill hoggs (Morgan *et al.*, 1950). In hill hoggs the autumn worm burden consists mainly of *Ostertagia circumcincta, O. trifurcata, Trichostrongylus axei, T. vitrinus* and *T. colubriformis,* with some *Nematodirus* spp., a few *Bunostomum trigonocephalum, Oesophagostomum venulosum* and *Trichuris ovis* and, in some sheep, a few *Haemonchus contortus* and *Chabertia ovina;* in spring *Ostertagia* spp., *T. axei, Nematodirus* spp.,

* Based on data collected with a grant from the Agricultural Research Council to the Department of Zoology of the University of Edinburgh.

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† " Hogg " is the name used in Scotland for a sheep from when it is weaned until it is shorn, that is from about five to fourteen months old.

and *B. trigonocephalum*, and in late spring *H. contortus*, are approximately twice as numerous as they are in the autumn, and the increases of the infestations of *T. vitrinus* with *T. colubriformis*, of *Oe. venulosum* and of *C. ovina* are more than double. The spring rise follows an earlier increase in the numbers of larvae and of immature worms in the lumen of the abomasum and to a lesser extent, in the lumen of the small intestine (Morgan *et al.*, 1951; Parnell *et al.*, 1954 and Parnell, 1956). Observations by Wilson *et al.* (1953)* who examined the mucosa of the alimentary tracts of sheep from a West Coast farm, suggest that the numbers of larvae which lie dormant in the mucosa are insufficient to account for the numbers involved in the spring rise, which, moreover, includes some species which, unlike *Ostertagia* spp. (Sommerville, 1954), are not known to have a histotropic phase, for example, *T. axei*, which has been shown by Vegors (1958) not to be subject to arrested development in cattle; it has been found, however, that one species of *Trichostrongylus*, *T. retortaeformis*, can remain undeveloped for over three months in resistant rabbits (Taylor and Michel, 1953). Furthermore, the interpretation of the significance of worm egg counts can be complicated by the effect of the level of resistance of the host; for example, Stewart and Gordon (1958) have found that very few eggs are laid by adult *Trichostrongylus colubriformis* in sheep which have become resistant.

In these trials the treatments were timed, as were those with hill hoggs, to reduce the heavy autumn and late winter or early spring worm infestations, and also to reduce the winter infestations, because the quality of the grazing is always very low in winter. Between autumn and spring, hoggs, both on the hill and on in-bye fields, lose a considerable amount of body weight, which often is as much as ten to twenty per cent. of their autumn weight. Except for the fact that it is known that in Scotland helminths add to the loss, the problem is not unlike that of some districts in the winter rainfall areas of Australia, where unthriftiness of hoggs (weaners) is a serious problem, when the nutritional level of the grazing falls in summer (Bennetts, 1958; Engel, 1958, Mulhearn, 1958).

Materials and Methods

Scottish Blackface hoggs on three farms were used in these trials. One farm—A—was on the Southern Uplands and the other two—B and C—were on the south face of the Pentland Hills. The minimum height of the fields was about 700 feet above sea level and some were higher.

Each hogg was identified individually either by numbered earrings or by marks on the horns.

In all these trials the drenched and undrenched control hoggs were running together; there was, therefore, the probability that the effect of drenching was reduced because the drenched hoggs would have been subjected to a greater opportunity for

* A compressorium was used and it is possible that we should have found more larvae if a digestion technique had been employed.

reinfestation than if all the sheep had been drenched, and the control hoggs would have been exposed to fewer larvae than if all the hoggs were carrying normal infestations.

In the first years of these trials each group of hoggs was given the same anthelmintic at each drenching, but later the anthelmintics were alternated as it was thought that better results, or at least equally good results, might be obtained without using phenothiazine so often, and that, if carbon tetrachloride could be included in the rotation in the late autumn or winter, it could have a dual purpose on farms infested with liver fluke—*Fasciola hepatica.*

In all there were nine trials, with 25 groups of drenched hoggs. In each trial the hoggs were divided by eye into approximately even groups, usually by dividing the largest hoggs into the required number of groups, then the smallest hoggs were allocated to the groups, and finally the average sized hoggs were split between the groups; lots were then drawn to decide the treatment for each group. The numbers in the groups at the start of the trials never varied by more than one. Worm egg counts were not made until after the first treatment; they were, therefore, the result of random selection.

Four anthelmintics were used. Phenothiazine (" P ") was given as aqueous suspensions; in most trials the doses ranged from 26 g. up to 48 g., and usually were from about 30 g. to just over 40 g.; however, for three groups on farm A the doses ranged from 21 to 25 g. The quantities include the weights of the dispersal agents. Unfortunately, no data are available on the particle sizes or purity of the phenothiazine; the doses, however, were comparatively large and it is probable that there should have been sufficient fine particles to have affected *Ostertagia* spp. and *Trichostrongylus* spp. Gordon (1956), Whitten (1956), Douglas *et al.* (1956 and 1959), Thomas and Elliot (1957), and Kingsbury (1958) have all shown that for a high degree of efficiency against *Ostertagia* spp. and *Trichostrongylus* spp. it is essential that the phenothiazine should contain a considerable proportion of very fine particles, and Forsyth (1959) has also shown the necessity of its being at least 85 per cent. pure, and Baker *et al.* (1959) have demonstrated that purified phenothiazine can be slightly less fine than N. F. phenothiazine.

Carbon tetrachloride (" CCl_4 ") was given as one part in four parts of paraffin; the doses increased from 10 ml. of the mixture in the autumn up to 16 ml. later.

" C.N." was 2% copper sulphate +2% of 40% nicotine sulphate, which were mixed before use; this mixture was only given to two lots of hoggs; doses of between 25 and 32 ml. were used.

" N.C." was a commercial preparation, which when diluted contained 1.0% nicotine sulphate and 1.6% copper sulphate; the doses varied from 32 ml. to 50 ml. depending on the age of the hoggs. There was also a trace of cobalt in this preparation; it seems unlikely, however, that the cobalt could have had any marked effect on the health of the hoggs, as this drench was given from bottles, and, therefore, the oesophageal groove would have been closed by the copper sulphate in most of the sheep; moreover, there was an interval of about two months between the earlier drenchings and only slightly less before the final drenchings. On the other hand, cobalt deficiency was suspected on some parts of farm A.

The effects of the drenchings, one or two during the autumn, one in early winter, and one in late winter or early spring, were measured by body and fleece weights and

TABLE 1

The average " Other Strongyle " worm egg counts, as eggs per gramme, body weights in lb. and fleece weights in oz. of the undosed control hoggs.

TRIAL No.	FARM	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		JANUARY		FLEECE
		e.p.g.	wt. in lb.	e.p.g.	wt. in lb.	e.p.g.	wt. in lb.	e.p.g.	wt. in lb.	e.p.g.	wt. in lb.	wt. in oz.
1	A	234	61·5	366	—	353	66·9	—	—	419	62·4	73
2	A	1115	55·4	935	60·1	795	62·8	262	59·5	332	60·9	71
3	C	—	—	—	—	547	71·4	350	65·3	697	65·1	72
4	A	—	—	366	54·7	672	58·4	466	58·7	331	54·3	65
5	B	—	—	—	—	642	70·0	373	67·5	309	68·0	79
6	C	—	—	472	68·5	—	—	537	71·0	393	67·1	65
7	A*	167	61·2	340	65·4	—	—	297	54·3	404	55·7	63
8	B	—	—	375	67·3	131	73·9	—	—	100	71·4	83
9a	C	531	69·1	—	—	443	78·9	—	—	308	73·9	73
9b		444	67·0	—	—	256	76·0	—	—	250	70·6	79
9c		462	66·8	—	—	712	73·6	—	—	159	70·2	100

TRIAL No.	FARM	FEBRUARY		MARCH		APRIL		MAY		JUNE		FLEECE
		e.p.g.	wt. in lb.	e.p.g.	wt. in lb.	e.p.g.	wt. in lb.	e.p.g.	wt. in lb.	e.p.g.	wt. in lb.	wt. in oz.
1	A	213	56·4	291	53·8	303	53·1	116	62·8	97	81·9	73
2	A	378	56·8	505	53·7	742	52·6	124	62·3	126	73·4	71
3	C	410	62·7	707	60·9	521	65·2	—	—	1432	78·2	72
4	A	434	51·1	297	49·3	—	—	250	54·7	237	74·6	65
		370	48·2									
5	B	159	66·5	254	63·4	—	—	—	—	75	85·2	79
		170	63·6									
6	C	282	67·9	339	63·1	—	—	—	—	162	84·1	65
				395	61·8							
7	A*	963	50·8	360	53·1	57	66·7	—	—	47	82·2	63
8	B	63	70·3	19	76·0	—	—	—	—	47	95·1	83
9a	C	—	—	296	62·8	—	—	—	—	246	83·1	73
9b		234	63·6	150	68·0	—	—	—	—	406	84·1	79
9c		76	75·1	91	82·4	—	—	—	—	88	97·3	100

* In late winter two control hoggs were drenched to save their lives.

by egg counts of the " Other Strongyles ", of *Nematodirus* spp. and of *Strongyloides papillosus;* however, the egg counts of the two latter were usually very low. The modified McMaster worm egg counting technique described by Morgan *et al.* (1950) was used for making the worm egg counts; the number of eggs counted in four slides multiplied by 50 gives the number of eggs per gramme.

Differences between the drenched and undrenched control hoggs were tested for statistical significance only at the times when the differences would be of most practical importance. Three asterisks (***) shows that there was a statistically significant difference at the 0.1% level; two asterisks (**) indicate a 1.0% significance; one asterisk (*) shows significance at the 5.0% level, and " ns " indicates that the difference was not statistically significant.

When worm egg counts were tested for statistical significance the transformation $y—100 \log_{10} (1+x)$ was used (Paver *et al.*, 1955), when x was the number of eggs counted in four cells of the McMaster worm egg counting slides. When the differences between the " O.S." egg counts of the drenched and undrenched control hoggs were reduced to percentages of the counts of the undrenched hoggs, the means of the untransformed counts were used.

Results

Controls

Table I shows the " O.S." egg counts, body and fleece weights of the undrenched control hoggs. This table shows that in most trials which ran from autumn until the end of the following spring, the " O.S." egg counts varied from under a hundred eggs per gramme to, usually, considerably under a thousand eggs per gramme. Omitting group 9c, which was wintered " away ", and group 8, which was also on comparatively good grazing, the body weight increases, from the start to the finish of the trials, varied from 6.8 lb. to 21.0 lb. with most of the increases between 14 and 20 lb. With the exceptions of groups 8 and 9c all groups lost weight during the winter; between late winter or early spring and the end of the trials in June the average increases in body weights ranged from 17.3 to 31.4 lb. Again excluding groups 8 and 9c, the average fleece weights ranged from 3.9 lb. to 4.9 lb.

Table II shows the number of hoggs, including the undrenched control hoggs, and the number of treated groups in each trial, and the dates on which the hoggs were drenched.

Phenothiazine

Table III shows the effects of drenching hoggs with 26 to 48 g. of phenothiazine; in three trials they were drenched four times and in four trials they were drenched three times—once instead of twice in the autumn. When the worm egg counts were made about a month after each drenching in the 4-dose trials, the average counts of the drenching hoggs were 12 to 49 per cent. in autumn, 11 to 61 per cent. in January, 14 to 58 per cent. in February or March, and 29 to 62 per cent. in spring of the average counts of the undrenched control hoggs. The average increase in body weights was 4.3 lb. after allowance had been made for the differences in weights at the start of the trials (with significance of 0.1%) and the average increase in fleece weights was 5.4 oz., which was not significant. The 3-dose trials resulted in " O.S." egg counts of

TABLE II

The dates on which the hoggs were drenched, the total number of sheep in each trial and the number of different treatments.

TRIAL	NUMBER OF SHEEP	NUMBER OF TEST TREATMENTS	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL
1	80	4	27	—	—	13	—	13	—	4
2	98	4	26	—	—	12	—	9	—	5
3	48	2	—	—	—	13	—	15	—	2
4	81	4	—	2	—	7	—	5	26	—
5	35	2	—	—	8	—	—	4	31	—
6	96	2	—	17	—	—	—	6	29	—
7	45	2	30	—	—	—	22	—	17	—
8	47	2	—	16	—	—	23	—	25	—
9	98	3	29	—	—	—	8	—	30	—

the drenched hoggs ranging from 21 to 76 per cent. of those of the controls in autumn or early winter, from 10 to 131 per cent. in winter, and 51 to 237 per cent. in spring, when some of the counts were made over two months after the drenching; the majority of the average counts of the drenched hoggs were lower than those of the controls, but four in trial 5 and the final count in trial 3 were higher. The corrected* increase in average body weights was 4.8 lb. and the difference in fleece weights was an increase of 8.0 oz.; they were both significant at 0.1%.

Table IV shows the effects of 21-25 g. doses of phenothiazine given four times. In autumn the " O.S." egg counts of the drenched hoggs averaged 29 to 58 per cent. of the controls, in January 22 to 48 per cent., in late winter 41 to 49 per cent., and in May 16 to 89 per cent. The average corrected increase in body weight over that of the undrenched hoggs was 3.0 lb., significant at 0.1%, and the average gain in fleece weight was 4.1 oz., which was not significant. However, the first trial produced a most satisfactory body weight gain, while the second and third did not. The first drenching in trial 2 was with the same brand of phenothiazine that was used for trial 1, but the subsequent drenchings were with another brand. The same brands were used in the trials with heavier doses of phenothiazine, but in that series there were comparatively small variations in the body weight gains of the treated hoggs in the different trials, perhaps because with the heavier doses there were sufficient fine particles of phenothiazine to reduce the number of *Ostertagia* spp. and *Trichostrongylus* spp.; on the other hand in the trials with the lighter doses of phenothiazine the worm egg counts were reduced considerably.

Carbon Tetrachloride

Table V gives the results obtained with four doses of 10-15 ml. of a 1:4 mixture of carbon tetrachloride and liquid paraffin. The autumn, January, late winter and May " O.S. " egg counts of the treated hoggs averaged 43 to 67 per cent., 23 to 55 per cent., 38 to 109 per cent. and 19 to 200 per cent. respectively of the average of the undosed control hoggs. The average differences of increases in the body and fleece weights were 2.0 lb., and 2.1 oz.: the former was significant at 5.0% and the latter was not significant.

Copper-nicotine Mixture

Because the effects on the body weights were not promising, only two groups of hoggs were drenched with 2% copper sulphate with 2% nicotine sulphate (" CN "), four doses of 25 to 32 ml. were used. Table VI gives the results. Most of the " O.S." egg counts were lower than those of the undosed controls about a month after drenching; 43 and 66 per cent. in October, 55 and 65 per cent. in January, 44 and 238 per cent. in March, and 53 and 78 per cent. in May; the highest percentages were in trial 1 and were not statistically significant. However, the corrected average body weight difference of the drenched hoggs was 0.7 lb. less than that of the average of the undrenched hoggs, but the fleece weights averaged 3.6 oz. heavier; neither difference

* Mean treatment final wt.—Mean control final wt.—b (mean initial treatment wt.—mean initial control wt.) where b = regression coefficient of final control wt. on initial control weight.

TABLE III

Phenothiazine in doses of 26–48 grammes

The effects on the " Other Strongyle " egg counts are shown by giving those of the drenched hoggs as percentages of the undrenched control hoggs, using untransformed counts.

TRIAL	SEPT.	OCTOBER		NOVEMBER		DEC.	JANUARY		FEBRUARY		MARCH		APRIL		MAY	JUNE
	late	early	late	early	late	early	early	late	early	late	early	late	early	late	early	late
4-dose Trials																
1	*138*	—	49*	—	50	—	11‡	—	*65*	—	—	58ns	*68*	—	62ns	39
2	*60*	—	12	—	63	*83*	17	—	*19*	—	18	—	*20*	—	34	5
4	—	*125*	—	40	—	*74*	61	—	*53*	14	—	*51*	—	—	29	28
3-dose Trials																
3	—	—	—	107	—	*106*	—	21	*76*	—	23	—	*25*	—	—	156
5	—	—	—	*79*	—	76	—	119	*251*	131	—	*79*	—	—	—	237
6	—	—	*92*	—	—	36	—	64	*56*	—	27	*31*	—	—	—	53
7	104	—	44	—	—	48	—	69	—	10	—	25	—	51	—	15

The effects of drenching on body weights are shown by comparing the average gains or losses of the drenched hoggs with those of the undrenched control hoggs during the period since the previous weighing, in lb. The corrected differences in the average body weights over the whole trial and the differences in average fleece weights, in oz., are also shown. The original difference in the average weights of the drenched compared to the control hoggs at the start of the trials are shown, in brackets.

TRIAL	SEPT.	OCTOBER		NOVEMBER		DEC.	JANUARY		FEBRUARY		MARCH		APRIL		MAY	JUNE
	late	early	late	early	late	early	early	late	early	late	early	late	early	late	early	late
***4*-dose Trials**																
1	*(−7·8)*	—	—	—	+3·1	—	+0·4	—	*+2·3*	—	+1·1	—	*+1·3*	—	−0·1	−2.1
2	*(+2·4)*	—	+1·0	—	+0·8	*−1·0*	+2·1	—	*+0·9*	—	+0·6	—	*−2·4*	—	0	+1·0
4	—	*+(1·0)*	—	+1·2	—	*+0·5*	+1·5	—	*−1·1*	+0·8	—	*+0·5*	—	—	0	0
***3*-dose Trials**																

4	—	*+(1·0)*	—	+1·2	—	*+0·5*	+1·5	—	*−1·1*	+0·8	—	*+0·5*	—	—	0	0
***3*-dose Trials**																
3	—	—	—	*(+2·8)*	—	*(+0·7)*	—	+2·2	*−0·6*	—	+0·9	—	*−0·4*	—	—	+1·7
5	—	—	—	*(+4·1)*	—	+1·1	—	+0·1	*+2·9*	−2·4	—	*+1·6*	—	—	—	+2·9
6	—	—	*(+0·5)*	—	—	0	—	+0·2	*+0·2*	—	+0·4	*+0·3*	—	—	—	+2·4
7	*(−1·2)*	—	−1·1	—	—	+0·2	—	*+0·5*	—	−0·4	—	*+2·2*	—	+1·2	—	+1·3

ns — Not statistically significant.

* — Statistically significant at 5 per cent.

† — Statistically significant at 1 per cent.

‡ — Statistically significant at 0·1 per cent.

TRIALS	Corrected overall difference, lb.	Fleece weight difference, oz.
4-dose Trials		
1	+4·1†	+3·0 ns
2	+3·5*	+7·5*
4	+3·3†	+5·4 ns
3-dose Trials		
3	+4·6*	+5·0 ns
5	+5·9*	+3·6 ns
6	+3·9†	+11·7‡
7	+4·2†	+7·7 ns
Average of 4-dose trials	+4·3‡	+5·4 ns
Average of 3-dose trials	+4·8‡	+8·0‡
Average of all trials	+4·3‡	+6·9‡

The times of drenching are shown by *italic figures* in the worm egg per cent and body weight differences.

TABLE IV

Phenothiazine in doses of 21-25 grammes ; 4 drenchings.

The effects on the " Other Strongyle " egg counts—(see Table III).

TRIAL	SEPT.	OCTOBER		NOVEMBER		DEC.	JAN.	FEBRUARY		MARCH		APRIL	MAY	JUNE
	late	early	late	early	late	early	early	early	late	early	late	early	early	early
1	*75*	—	58*	—	100	—	24†	*50*	—	—	49 ns	*31*	89 ns	113
2	*54*	—	29	—	67	*63*	22	*62*	—	44	—	*26*	16	6
4	—	*137*	—	40	—	*75*	48	*67*	41	—	*27*	—	25	76

The effects on body weights—(see Table III).

1	*(−1·2)*	—	—	—	+3·1	—	−0·1	*+0·4*	—	+0·8	—	*+1·0*	−9·6	+2·5
2	*(+4·2)*	—	−0·4	—	−0·8	*−0·3*	+0·8	*+0·6*	—	+0·3	—	*−0·7*	+0·2	+1·0
4	—	*(+0·8)*	—	+0·2	—	*+0·3*	+1·0	*−0·6*	+0·7	—	*−0·6*	—	+0·8	−1·4

TRIAL	Corrected overall difference, lb.	Fleece weight difference, oz.
1	+7·6‡	+3·4 ns
2	+1·7 ns	+7·1 ns
4	+9·4 ns	+0·9 ns
Average of 3 trials	+3·0‡	+4·1 ns

In trial 1 there had been a gain of 2·9 lb. by January, which was significant at the 5·0% level.
4·4 lb. by March, which was significant at the 5·0% level.
4·8 lb. by May, which was significant at the 1·0% level.

TABLE V

1 : 4 Mixture of carbon tetrachloride in doses of 10-15 ml. ; 4 drenchings.

The effects on the " Other Strongyle " egg counts—(see Table III).

TRIAL	SEPT.	OCTOBER		NOVEMBER		DEC.	JAN.	FEBRUARY		MARCH		APRIL	MAY	JUNE
	late	early	late	early	late	early	early	early	late	early	late	early	early	early
1	*97*	—	67 ns	—	105	—	55 ns	*77*	—	—	109 ns	*72*	200 ns	193
2	*62*	—	55	—	94	*123*	23	*25*	—	38	—	*19*	53	34
4	—	*133*	—	43	—	*74*	54	*80*	87	—	*53*	—	19	46
The effects on body weights—(see Table III)														
1	*(−6·4)*	—	—	—	+3·5	—	0	*+0·5*	—	+0·8	—	*+1·0*	−1·7	−1·3
2	*(+3·1)*	—	−1·2	—	+0·9	*−0·7*	−0·0	*+2·5*	—	−0·5	—	*−0·2*	−0·5	+2·3
4	—	*(+0·4)*	—	−0·1	—	*−0·5*	+0·6	*−0·1*	+0·6	—	*−0·3*	—	+0·3	+0·5

TRIAL	Corrected overall difference, lb.	Fleece weight difference, oz.
1	+1·2 ns	+0·1 ns
2	+2·4 ns	+6·3 ns
4	+1·0 ns	−0·6 ns
Average of 3 trials	+2·0*	+2·1 ns

In trial 1 there had been a gain of +3·5 lb. by January, which was significant at the 5% level.
+4·8 lb. by March, which was not significant.
+4·1 lb. by May, which was not significant.

TABLE VI

2% copper sulphate +2% nicotine sulphate ("C.N.") in doses of 25-32 ml. ; 4 drenchings

The effects on the "Other Strongyle" egg counts—(see Table III).

TRIAL	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MARCH		APRIL	MAY	JUNE
	late	late	late	early	early	early	early	late	early	early	early
1	*107*	66 ns	80	—	65 ns	*164*	—	238 *ns	*41*	78 ns	80
2	*42*	43	107	*172*	55	*47*	44	—	*19*	53	34

The effects on body weights—(see Table III)

1	(*−3·2*)	—	+1·2	—	+0·9	*−0·6*	—	+0·8	*−0·3*	−0·1	−2·2
2	(*+2·6*)	+0·3	+1·1	*−1·2*	−0·1	*+0·9*	−0·4	—	*−1·4*	+0·3	−1·0

TRIAL	Corrected overall difference, lb.	Fleece weight difference, oz.
1	−1·2 ns	−0·9 ns
2	−0·8 ns	+7·1 ns
Average of 2 trials	−0·7 ns	+3·6 ns

In trial 1 there had been a gain of +2·1 lb. by January, which was not significant.
+2·3 lb. by March, which was not significant.
+1·9 lb. by May, which was not significant.

* One hogg, with a worm egg count of 7,000 e.p.g., died soon after this sample was taken ; in February its count had been 2,550 e.p.g. ; without this hogg the differences would have been 127 per cent and 94 per cent.

TABLE VII

1.0% nicotine sulphate + 1.6% copper sulphate ("N.C.") in doses of 31-36 ml.

The effects on the "Other Strongyle" egg counts—(See Table III).

TRIAL	OCTOBER		NOV.	DEC.	JANUARY		FEBRUARY		MARCH		APRIL	MAY	JUNE
	early	late	early	early	early	late	early	late	early	late	early	early	early
4-dose Trial													
4	*73*	—	55	*99*	60	—	*90*	60	—	*31*	—	7	63
3-dose Trials													
3	—	—	160	*113*	—	51	*129*	—	73	—	*65*	—	73
5	—	—	*108*	122	—	155	*145*	176	—	*79*	—	—	52
6	—	*117*	—	102	—	83	*74*	—	49	*52*	—	—	63

The effects on body weights—(see Table III).

4-dose Trial													
4	(+1·0)	—	−0·4	*+1·6*	+1·1	—	*+0·9*	−1·1	—	*+0·1*	—	+1·9	+0·6
3-dose Trials													
3	—	—	(+2·0)	(*+2·9*)	—	+0·2	*+2·0*	—	+0·5	—	*+0·4*	—	+1·8
5	—	—	(*−0·1*)	+1·4	—	−0·3	*+2·6*	−2·7	—	*+1·2*	—	—	+3·6
6	—	(*−0·7*)	—	+0·8	—	−0·9	*−0·6*	—	+0·9	*+0·2*	—	—	+3·4

	Corrected overall difference, lb.	Fleece weight difference, oz.
4-dose Trial		
4	+4·5‡	−1·3 ns
3-dose Trails		
3	+6·1†	+9·4*
5	+5·4†	+6·1 ns
6	+5·6‡	+7·7*
Average of 4 trials	+5·1‡	+5·9†

was statistically significant. In both trials the body weights of the drenched hoggs increased less than those of the controls, but in one trial their fleece weights were heavier.

Table VII shows the effects of " NC "—1.0% nicotine sulphate + 1.6% copper sulphate, given in doses of 31 to 46 ml. In one trial four doses and in the other three trials three doses were used; the former gave slightly less satisfactory body and fleece weight gains. Five or six weeks after the autumn drenchings the " O.S." egg counts of the drenched hoggs averaged 51 to 122 per cent. of those of the undrenched hoggs; in winter 49 to 176 per cent. and, after intervals of several weeks, 7 to 73 per cent. in the spring. In the four trials with this anthelmintic the body weights showed statistically significant increases over those of the undrenched control hoggs, these increases averaged 5.1 lb.; fleece weights were also heavier, with an average increase of 5.9 oz.; statistical significances were at the 0.1% and 1.0% levels respectively.

Anthelmintics Alternated

Table VIII shows the results obtained with 34-38 ml. " NC " in the autumn, followed by 45 g. phenothiazine in early January and 15 ml. of 1:4 carbon tetrachloride mixture in late winter. Following the drenching with " NC " the " O.S." egg counts averaged 83 and 90 per cent. of those of the controls; after the phenothiazine they fell to 18 and 35 per cent., and after the CCl_4 they were 28 and 65 per cent. The corrected gain in average body weights was 3.7 lb., with significance at the 1.0% level, and the gain in average fleece weights was 8.9 oz., which was significant at 5.0%. In a trial with hoggs wintered on the hill this succession of anthelmintics gave an average body weight gain of 0.3 ± 1.7 lb., and a fleece weight gain of 7.3 ± 4.3 oz. (Parnell *et al.*, 1955b).

One trial was made with phenothiazine in autumn, carbon tetrachloride mixture in early winter and " NC " in late March; Table IX gives the details. After each drenching the average " O.S." egg count was less than that of the controls. The body weight gain over that of the undrenched hoggs was not significant at 2.5 lb., but the fleece weight gain of 9.2 oz. was significant at the 5.0% level.

Four groups of hoggs, all on farm C, were drenched with 33 ml. of " NC " in the autumn and with 36 to 42 g. of phenothiazine in early winter and early spring. Table X gives the results. Each drenched group with its undrenched control group was grazed in a different way; when grazed on the hill during the autumn and winter, the drenched hoggs gained 2.3 ± 2.0 lb. in average body weight and 13.5 ± 5.1 oz. in average fleece weight more than their controls (Parnell *et al.*, 1955b); another (trial 9a) was grazed from the end of September until 8th January on the in-bye fields and then put on the hill; a third group (trial 9b) was grazed on the in-bye fields during the autumn and winter, and the fourth group (trial 9c) was grazed on " clean " pastures on lower ground a few miles from the hill during the autumn and the winter. The method of wintering affected the body and fleece weights of the hoggs. During the period of the trial the undrenched control hoggs wintered on the hill gained an average of 13.8 lb.; those in-bye during the autumn and wintered on the hill (9a) gained 14.0 lb.; those grazed during both the autumn and the winter in-bye (9b) increased

TABLE VIII

34-38 ml. "N.C." in the autumn, 44-45 grammes phenothiazine in early winter, and 14-15 ml. carbon tetrachloride mixture in late winter.

The effects on the "Other Strongyle" egg counts—(see Table III).

TRIAL	SEPT. late	OCT. late	NOV. late	DEC. early	JAN. late	FEB. late	MARCH late	APRIL late	JUNE early	Corrected overall differences, lb.	Fleece weight differences, oz.
7	*133*	106	—	83	*67*	18	*15*	65	64	+4·5†	+14·6†
8	—	*89*	90	—	*167*	35	*15*	—	28	+3·8*	+4·8 ns
									Average of 2 trials	+3·7†	+8·9*

The effects on body weights—(see Table III).

7	(*−1·9*)	+0·6	—	+1·0	*−0·1*	0	*+1·3*	−1·0	+2·4	+4·5†	+14·6†
8	—	(*+3·5*)	−0·9	—	*−0·3*	+1·7	*+1·5*	—	+2·1	+3·8*	+4·8 ns
									Average of 2 trials	+3·7†	+8·9*

71.1 lb. and those on the lower fields (9c) gained 30.7 lb.; their fleece weights averaged 63 oz., 73 oz., 79 oz. and 100 oz. respectively. At the end of the trial in every group the average body and fleece weights of the drenched hoggs were heavier than those of their undrenched controls, except the fleece weights of 9c.; in group 9a the gains were 5.7 lb. and 5.9 oz.; in group 9b 3.6 lb. and 5.1 oz. and in group 9c 3.1 lb. and a loss of 5.1 oz.; the body weight gains in trials 9a and 9b were significant at the 5.0% level; the other differences were not significant. The intervals between drenchings and the subsequent worm egg counts were rather long, but phenothiazine appeared to lower the counts; except after the final drenching of the hoggs on the low ground fields (9c), but the " O.S." egg counts of the controls were already low.

Strongyloides papillosus

The eggs of *Strongyloides papillosus* occurred erratically in very small numbers in all groups, they were perhaps slightly more scarce at the end of the trials in June than when the hoggs were younger.

Nematodirus spp.

The egg counts of *Nematodirus* spp. were also low. Statistical analyses of the effect of phenothiazine on them were made for trials 1 and 2; there was a comparative increase after one January drenching with 22 g. in one group, which was statistically significant, but only at the 5.0% level; the other drenchings with phenothiazine had no apparent effect on the light infestations of this genus.

Deaths

The death rates were 4.9 per cent. in those treated with phenothiazine; 4.8 per cent. in those drenched with " CN " or " NC " and 3.2 per cent. in the trials with more than one anthelmintic; no hogg died in the groups treated with carbon tetrachloride. In addition two of the controls would probably have died from " black scours " if they had not been drenched, which would have raised the control percentage to 5.8. One hogg died as the result of phenothiazine idiosyncrasy (Dunn, 1953); one hogg drenched with phenothiazine died from inhalation pneumonia and in one group of 15 hoggs drenched with phenothiazine two died of entero-toxaemia, one the following day, before the phenothiazine had reached the large intestine, the other six days after drenching. One hogg drenched with " NC " was slaughtered two days later as it showed complete paralysis of the throat region; it was thought possible that this was the result of an idiosyncrasy to the drench.

Discussion

In Scotland *Ostertagia* spp. and *Trichostrongylus* spp. are the most numerous genera which parasitise hill sheep, therefore, worm egg counts of only a few hundred eggs per gramme indicate infestations which reduce the body and fleece weights of sheep, as both genera are poor egg layers. Moreover, unless they are being hand fed, the grazing is seldom sufficiently nutritious for hoggs not to lose weight during the winter. These trials were, therefore, designed to reduce the worm burdens of the hoggs in the autumn, so that the hoggs would continue to gain weight for as long as

TABLE IX

42 grammes phenothiazine in the autumn, 16 ml. carbon tetrachloride mixture in early winter, and 50 ml. "N.C." in late March.

The effects on the "Other Strongyle" egg counts—(see Table III).

TRIAL	OCTOBER late	NOVEMBER late	JANUARY late	FEBRUARY late	MARCH late	JUNE early
8	*79*	*67*	*160*	*54*	*131*	47

TRIAL	Corrected overall differences, lb.	Fleece weight differences, oz.
8	+2·5 ns	+9·2*

The effects on body weights—(see Table III).

TRIAL						
8	(+5·7)	−1·2	+0·2	−0·3	+3·0	+1·7

possible; to reduce the worm infestations in early winter, although infestations are at their lowest then, in order that the check caused by lack of nutritious keep would be as slight as possible, and finally to reduce the worm numbers at the time of the " spring rise ".

The " O.S." egg counts in most of the trials were considerably reduced; they suggest, however, that quite appreciable worm infestations remained. In practically every trial, except in the two with " CN "; the body and fleece weights were increased. These increases were statistically significant for either body or fleece weights or both in most of the trials; exceptions were two of the three trials with 21-25 g. phenothiazine, the three trials with carbon tetrachloride and the trial with " NC " followed by phenothiazine on hoggs on the low ground fields (9c) which produced a gain in body weights but a loss in fleece weights, which were not statistically significant.

The limited number of comparisons between four drenchings with phenothiazine, including two in the autumn, and three drenchings with phenothiazine, including only one in the autumn, suggest that the three drench programme is likely to be just as effective.

Gordon (1953) has found that dosing worm free sheep with phenothiazine may cause a loss of body weight, and it was suggested that when Blackface lambs were dosed with this anthelmintic the benefit from the reduction in their worm burdens was not always sufficient to compensate for the loss of body weight caused by the phenothiazine (Parnell *et al.* 1955a). It is possible that in these trials phenothiazine caused a drop in body weight but that the reduction in the worm burdens has more than compensated for it in most sheep.

The comparative failure of the smaller doses of phenothiazine in two of the three trials suggests that a higher dose rate was necessary or that the phenothiazine may not have consisted of very fine particles, which, with a high degree of purity, are essential for effective drenching against *Ostertagia* spp. and *Trichostrongylus* spp.

The doses of carbon tetrachloride were those recommended by the sellers of the mixture for the removal of " worms' '. This anthelmintic reduced the " O.S." egg counts; however, it did not increase significantly either body or fleece weights. Particularly in the west of Scotland, where liver fluke is prevalent, an anthelmintic which would be effective against both fluke and " Other Strongyles " at the same time would be of great value.

The difference between the effects of " CN " and " NC " are surprising; both appeared to cause some reduction in the worm egg counts, but the former in both trials gave no increase in body weights, while the latter gave body weight increases which were significant at the 0.1% or at the 1.0% levels. As the " NC " was given at intervals of several weeks and was given by bottle it should be unlikely that the cobalt was the cause of the marked difference in effect. Slightly smaller quantities of " CN " were given, but the solutions were more concentrated. As " CN " was ineffective it also seems unlikely that the copper made good a sub-clinical copper deficiency. Only one of the trials with " NC " was on the farm on which " CN " had been tried.

Too few trials were completed with the anthelmintics being alternated to determine which programme of drenching is likely to be most effective or economic.

TABLE X

33 ml. of "N.C." in autumn and 36-42 grammes phenothiazine in early winter and early spring, on various grazings.

The effects on the "Other Strongyle" egg counts—(see Table III).

TRIAL	SEPTEMBER late	NOVEMBER late	JANUARY early	FEBRUARY late	MARCH late	JUNE late	Corrected overall difference, lb.	Fleece weight difference, oz.
9a	*115*	95	*91*	—	*51*	66		
9b	*84*	122	*72*	42	*56*	31		
9c	*129*	76	*148*	86	*69*	264		
The effects on body weights—(see Table III).								
9a	*(+1·0)*	−1·0	*+0·3*	—	*+4·8*	+0·9	+5·7*	+5·9 ns
9b	*(+1·4)*	−1·5	*+0·5*	−0·1	*+0·1*	+4·8	+3·6*	+5·1 ns
9c	*(+2·2)*	+0·1	*−0·3*	+0·8	*+0·7*	+1·7	+3·1 ns	−5·1 ns

Group a were grazed on in-bye fields in the autumn, but on the hill during the winter.
Group b were grazed on in-bye fields in the autumn and winter.
Group c were grazed on clean low ground fields in the autumn and winter.
Hoggs on the in-bye fields were also hand fed.
Another group were grazed on the hill during the autumn and winter (Parnell *et al.* 1955).

These trials and those on hill wintered hoggs, leave no doubt that the body and fleece weights of ewe hoggs can be increased by anthelmintic drenching. Unfortunately insufficient trials have been completed to be able to give firm recommendations on when and with which anthelmintic hoggs should be drenched to obtain the maximum effects.

In these trials the greatest average fleece weight increase of 14.6 oz. was obtained with " NC " in the autumn, followed by phenothiazine in the early winter, and carbon tetrachloride in the late winter, but the other trial with these anthelmintics gave only a 4.8 oz. increase. The second heaviest increase of 11.7 oz. was obtained with three doses of phenothiazine.

The heaviest body weight increase was an average of 7.6 lb. obtained with four 21-25 g. doses of phenothiazine, but in the two other trials with this quantity the increase was only 1.7 and 0.4 lb. The most consistent results were in four trials with " NC " and the four 3-dose trials with phenothiazine which gave average increases of 5.1 lb. and 4.8 lb. respectively. Table I shows that the different responses are unlikely to have been caused by initial differences in the levels of the infestations. Trials with phenothiazine consisting of fine particles and of a high degree of purity are obviously urgently needed.

Undoubtedly with better anthelmintics or better timing or both the worm burdens could be reduced more than they were in these trials. The body and fleece weight increases were obtained with worm egg counts which still averaged a few hundred eggs per gramme. Spedding and Brown (1957a) have shown that in lambs with infestations which averaged only 51 e.p.g. between mid-April and mid-July, with a maximum of 190 e.p.g., skeletal growth was reduced and their body weights averaged 11.9 lb. less than their worm-free controls, which was a difference in live weight gain of 33.5 *per cent.* During the following nine months the worm egg counts of this group of sheep, then hoggs, rose to a maximum of just under 1,000 e.p.g. with a mean of just over 300 e.p.g., while the controls carried only extremely light infestations; by the time the infested hoggs were just over a year old they averaged slightly under 100 lb. in body weight, while the controls were nearly 20 lb. heavier; these sub-clinical infestations also affected fleece weights, which averaged 27 oz. lighter than those of the controls (Spedding and Brown, 1957b and c). As these worm egg counts were comparable to those encountered in the drenching trials, but the weight differences were much greater, they suggest that there is scope for increased production of several pounds in body weights and many ounces of wool, if more effective drenching programmes could reduce further the worm burdens of hoggs. That most hoggs which are wintered on the hill or on the in-bye fields have a greater growth potential than they are able to express on the grazings is confirmed by the body and fleece weights of trial 9c.

The cash value of an increase in fleece weight is comparatively easy to assess, but the value of increased body weight in a stock hogg is much more difficult to estimate, because the evidence points to the fact that a ewe lamb or ewe hogg whose growth is checked will not grow to the size which it would otherwise attain and in its first breeding season its chances of rearing a lamb are decreased. It is probably, however, no exaggeration to put the cash value of a 5 lb. increase in body weight and a ½ lb. increase in fleece weights at over 10/- per head, which would be a useful addition to the economy of many hill farms.

Summary

Anthelmintic drenching trials on hoggs wintered on in-bye fields have shown that body and fleece weights can be increased by drenching at the right time with the right anthelmintic and that if phenothiazine, in doses which are effective against *Ostertagia* spp. and *Trichostrongylus* spp., and perhaps NC (1.0% nicotine sulphate + 1.6% copper sulphate) were used regularly the practice would be economically sound.

In three trials a dose of 26-48 g. phenothiazine given four times gave a highly significant increased body weight gain of 4.3 lb. and a fleece weight gain of 5.4 oz. which was not significant. In four trials drenchings with the same quantities of phenothiazine (26-48 g.) given three times gave an average gain of 4.8 lb. in body weight and 8.0 oz. in fleece weight, both of which were highly significant.

In three trials four drenchings with 21-25 g. phenothiazine gave average increases of 3.0 lb. in body weights and 4.1 oz. in fleece weights; in one trial, however, the body weight gains were considerablly greater than in the other two.

Three trials with four drenchings of 10-15 ml. of 1:4 carbon tetrachloride mixture were not statistically significant.

In two trials drenchings with 25-32 ml. of 2% copper sulphate + 2% nicotine sulphate (" CN ") given four times resulted in an average loss in body weight of 0.7 lb. and a slight gain in fleece weight of 3.6 oz.; neither was statistically significant. In four trials " NC ", 1.0% nicotine sulphate + 1.6% copper sulphate, in doses of 31-46 ml. gave highly significant increases in body weights of 5.1 lb. and in fleece weights of 5.9 oz.

Some trials with the anthelmintics being alternated were made, but more trials would be required to assess the best combination.

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These trials were carried out on the farms of the late Mr. A. Linton, of Mr. R. A. Johnstone and of the East of Scotland College of Agriculture; without their unfailing help and that of their shepherds, these observations could not have been made.

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TRANQUILLISING HORSES WITH PROMAZINE HYDROCHLORIDE

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Veterinary surgeons who are engaged in the equine field do not deal with docile patients always. Some horses cause endless trouble and anxiety and even danger to those who seek to handle them. Some are a menace to grooms, owners, veterinary surgeons, and farriers.

No doubt in most cases their conduct stems from fear and not antagonism, but there are other instances when it arises from an inherent viciousness. No matter the cause of the unwelcome behaviour, these horses can inflict serious injury on man or animal. These refractory reactions are manifested in " high strung ", quick-tempered horses, and in thoroughbred horses in particular. Quite often the animals are a " bundle of nerves " and the slightest stimulus brings lightning response. Horses have to be handled, shod, and clipped, and often these simple operations can be accomplished only when the animal is put under severe restraint, given a strong sedative, or anaesthetised.

Sedation is the ideal remedy, and a great variety of drugs have been used such as chloral, bromides, morphine, canabis indica, etc. None have proved to be consistently satisfactory. Their action is not certain, dosage has to be relatively high, the duration of sedation is unpredictable, and the horse's balance is upset and it may be many hours before it becomes normal again.

In recent times a number of drugs commonly called tranquillisers have been introduced into human medicine. They have the qualities of allaying fear, calming temper, and ease of administration. Their toxic effects are of low grade, and in the dosage required for sedation they are devoid of such side effects as interference with ambulation and balance.

In our practice much of the work has to do with the care and treatment of thoroughbred horses, and we meet with a fair number of patients who resent handling even for the simplest operations such as dental treatment and shoeing. Attending to these animals is often fraught with danger and at the best, much time is consumed. When the tranquillising drugs were introduced we determined to give them a trial. We were introduced to one which is a derivative of phenothiazine its generic name is promazine hydrochloride*. We were informed that it was of good repute in the medical field and that when used on short term projects side effects, if any, were not serious in nature or degree.

We have put this drug to test on many occasions and with welcome and satisfac-

* ' Sparine '—John Wyeth & Brother Limited.

tory effect, and append herewith a series of case reports in the hope that other veterinary surgeons may put it to the test and have the happy results which it has elicited in the majority of our cases.

1. A thoroughbred two-year-old filly, unbroken and unhandled. Haematoma right hind quarter. It was impossible to palpate the filly in the region of the injury without risk of being kicked. The only attendant available was a 15 year old girl. 5 ml. ' Sparine ' were given intravenously. In 15-20 minutes the temperament of filly was changed. She was easy to manage and to all intents and purposes acted like an animal that had been handled for years. The haematoma was lanced and drained under ordinary restraint and without using a local anaesthetic.

2. A thoroughbred brood mare, the dam of two classic winners. Tympanitic colic as the result of ingesting cut grass which had fermented due to heating. The mare had been in acute pain for 3 hours previous to attention. 5 ml. ' Sparine ' were given intravenously. Within 5 minutes all symptoms of pain had subsided. The mare lay down in a normal position. She was kept under constant supervision for 6 hours. She did not attempt to rise for approximately 3 hours, whereupon she had a small feed and drink. There was no re-occurrence. No other treatment was required or given.

3. A thoroughbred 2 year old filly, with a history of being a bad traveller, prone to sweat and be uneasy in the motor horse box. On three previous outings on the race-course she had become progressively more excited on each occasion that she ran. She became very " hotted " up in the parade ring and extremely unruly at the starting gate. It was arranged to give ' Sparine ' a trial on her next outing. A period of 3 hours was allowed within which she would leave her stable and race. 2 ml. ' Sparine ' were given intravenously and the animal was boxed within 15 minutes. She travelled very well, was extremely placid in the parade ring, became a little excited at the start but the excitement was trivial compared to her previous acrobatics.

4. A three year old thoroughbred colt in training. This was a difficult colt to handle even in normal stable procedure; it was particularly difficult when handled around the head. It was noticed by the stable man to be hanging badly to the left (this condition is usually due to some tooth defect, such as sharp molar teeth cutting through the inner aspect of the cheek, or the eruption of wolf teeth). An attempt was made to explore the mouth but this was found to be impossible using normal restraint. It is possible that this examination might have been done under great difficulty by the aid of extreme methods of restraint. 5 ml. ' Sparine ' were administered intravenously (with difficulty) and the animal was left for 30 minutes. There was a complete change in temperament. The mouth cavity was explored, a " wolf " tooth removed, and the molar teeth were filed. The only control used was a stable head collar.

5. A half-bred hunter gelding (a top grade, three day event horse in Ireland). The sheath and the upper aspect of the thighs were covered with papillomata or warty growths. These had been removed by surgical intervention on three occasions, under general anaesthesia. The gelding was very apprehensive of being handled in this area and in fact it would have been impossible to do so without serious risk to the operator. It was suggested to the owner that perhaps the largest of these growths might be

ligatured if the horse was put under the influence of ' Sparine '. 5 ml. ' Sparine ' were administered intravenously. It was completely ineffective. After allowing an interval of half an hour another 5 ml. ' Sparine ' were administered. This was of no avail also. After another half an hour 5 ml. ' Sparine ' were given. There was no effect other than slight incoordination of the hind quarter. The gelding remained acutely apprehensive of any approach to handling in the region of the sheath.

6. A thoroughbred unweaned foal. It was completely unhandled and had never worn a head collar. There was a six inch wound on inner aspect of forearm. Obviously the wound needed suturing and dressing. The foal was caught (necessitating three men). It was very excited and any attempt to suture would have been futile or at best the results would have been very unsatisfactory. 2 ml. ' Sparine ' were administered intravenously and the foal was left for 20 minutes. Then it was observed to be drowsy and docile. A local anaesthetic, necessitating at least 6 needle punctures, was injected around the periphery of the wound and without any difficulty. The wound was sutured and a dressing was applied. The foal hardly lifted a leg during the whole procedure. The foal remained dull and listless for approximately 5 hours when it commenced to suck its dam and become normal in behaviour.

Our experience with this product suggests that it might serve as a useful and convenient sedative when one has to deal with highly nervous or fractious horses and on such occasions as the following:

1. Prior to firing.
2. On clipping fractious horses.
3. In dental procedures.
4. On rectal examinations.
5. To facilitate the passage of a stomach tube.
6. Bad travellers.

Most animals come quickly under its sedative influence, but we have found that animals (as in case 5) which do not show response to the first injection seldom respond when the dose is repeated.

THE SEASONAL VARIATIONS OF STRONGYLE INFESTATIONS IN NIGERIAN ZEBU CATTLE

By

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Summary

An investigation of the seasonal availability of the infective larvae of *Haemonchus contortus, Trichostrongylus axei, T. colubriformis, Cooperia punctata, C. pectinata, Oesophagostomum radiatum* and *Bunostomum phlebotomum* for cattle in Northern Nigeria showed that only negligible infestations were acquired during the dry season and that animals infested during the previous rains carried infective material over to the next wet season.

The season when significant burdens of *Haemonchus, Cooperia, Oesophagostomum* and *Bunostomum* were acquired apparently extended from May to September when rainfall exceeded 6 inches per month, associated with monthly mean maximum temperatures of up to approximately 90°F. Only low *Trichostrongylus* burdens were encountered and it is suggested that high mean maximum temperatures during the wet season were unfavourable to the extra-host stages.

Temperature and rainfall requirements of the species encountered are discussed and an attempt is made to relate these data to the likelihood of outbreaks of helminthiasis occurring in various seasons and localities in the climatic area of Nigeria north of 9° latitude.

Introduction

Records compiled by Sprent (1946a) and Armour, Lee, Lindquist and Shonekan (unpublished data) list thirteen species of nematodes from the alimentary tract of cattle in Nigeria. These are *Haemonchus contortus, Cooperia pectinata, C. punctata, Trichostrongylus axei, T. colubriformis, Oesophagostomum radiatum, Bunostomum phlebotomum, Gaigeria pachyscelis, Strongyloides papillosus, Neoascaris vitulorum, Trichuris globulosa, T. ovis,* and *Gongylonema verrucosum.* Neither *Nematodirus* nor *Ostertagia* have, as yet, been encountered in cattle, sheep or goats though a careful search has been made for these parasites in many parts of the country. The available evidence indicates that *Haemonchus contortus, Bunostomum phlebotomum* and *Oesophagostomum radiatum* are of major economic importance. *Cooperia* infestations are almost invariably found but there is, as yet, no evidence to incriminate them as important pathogens in Nigeria. *Trichostrongylus* species also occur but no definite outbreaks of clinical disease associated with them have been encountered so far.

The extra-host stages of the strongyle worms are very susceptible to their environment and the climatic conditions of a region may exert a profound effect on the

geographical distribution and epizootiology of these infestations. With the exception of *Bunostomum phlebotomum,* which was studied by Sprent (1946 a to e) at Vom, little was known about the effect of the Nigerian climate on the strongyle infestations of cattle. A recent field investigation into the role of helminthiasis, and mineral and protein deficiencies in wet season unthriftiness of cattle at Shika Stock Farm, some 200 miles from Vom, enabled the course of untreated *Haemonchus, Cooperia, Trichostrongylus, Oesophagostomum* and *Bunostomum* burdens to be studied under known meteorological conditions.

The present report describes the helminthological findings which provide preliminary information on the effect of rainfall and temperatures on the seasonal and geographical distribution of the worm species encountered. It is hoped that this will enable control in the general climatic area of Northern Nigeria, especially with regard to predicting the likelihood of disease occurring in a given season and in postulating the most suitable timing of prophylactic medication, to be placed on a more reliable basis than has previously been possible.

Climatic Conditions of the Area

In Nigeria, north of approximately the ninth degree of latitude, there is a sharp division between the wet and the dry season with a progressive aridity and a shorter wet season towards the north, with moister areas at the higher altitudes.

The dry season begins in October and lasts until April or May. During November to February inclusive, rainfall is insignificant or nil but occasionally light showers occur during March in the wetter parts. These months experience very low relative humidities with monthly mean readings at noon falling to about 10 per cent. in the drier parts and seldom exceeding 25 per cent. in the moister areas.

The dry season is also characterised by considerable diurnal variation in temperature which is again greater in the extreme north. At Sokoto for example, which is near the Northern boundary, monthly mean temperatures of 90° to 100°F. are recorded from November to February with monthly mean minimum temperatures in the low sixties, arising to about 70°F. in March. At the other extreme, on the Bauchi Plateau, the variation is less marked and monthly mean maximum temperatures are in the eighties associated with monthly mean minimum readings of about 57° to 65°F.

The first significant rains fall between the end of March to May, depending on the locality, and precipitation generally reaches a peak in July or August. Heavy rainfall, which for the purposes of this paper is considered as approximately six inches or more per month, is usually encountered in the wetter parts during May to September, inclusive. In the dry areas heavy rainfall may be confined to two consecutive months from July to September. In all areas the general appearance of the country is again quite dry by October or November.

The wet season is associated with relative humidities of about 60 per cent. and monthly mean maximum temperatures of 75° to 95°F. These are slightly more in the drier parts of the north though mean maximum temperatures seldom exceed 93°F. when monthly rainfall reaches 4 to 5 inches. Monthly mean minimum wet season temperatures vary between 60° and 75°F. The climate of Shika occupies a median

position within the general range and meteorological data collected in the vicinity for 1956/57 are shown in Table I.

Design of the Investigation

Materials

Shika Stock Farm, which lies at an altitude of 2,000 feet, is situated near Zaria at about 11° 12″ North, 7° 34″ East. The herd consists of approximately 600 Zebu cattle. Calves are bucket fed and housed in pens with access to small exercising yards and are normally weaned when six to eight months old. On weaning they are turned out during the day to graze with older stock in the vicinity of the farm buildings and all weaned stock return to houses at night.

Between the 4th and 9th February, 1957, helminthological examinations were carried out on 15 unweaned calves and on 18 weaned animals drawn at random from the herd to obtain information on the worm burdens of the herd during the dry season. Early in May experimental groups were established in connection with an investigation involving sixty weaned calves, aged seven to eleven months, which were randomised into five equal groups. Helminthological examinations were made on all between the 14th and 17th May to study the worm burdens acquired during the early rains. Thereafter, Groups I, III and IV, which received no anthelmintic treatments during the investigation, were examined at weekly intervals until early November to provide information on the course of untreated worm infestations during the wet season.

All of the above animals were run as one herd during the day but at night they were housed in a shed divided equally into five pens with a separate compartment allocated to each group. Bedding was transferred from pen to pen at intervals in an attempt to create a uniform environment.

Experimental treatments given to groups which provide data for this report were as follows: —

Group I: Received no supplementary feeding.

Group III: Had access in a shed to a proprietary mineral lick from the 24th May to November, 1957. The composition of the lick was, Sodium Chloride 94.460%; Sulphur 1.020%; Calcium 0.570%; Iron 2,700 ppm; Phosphorus 2,000 ppm; Iodine 480 ppm; Manganese 300 ppm; Cobalt 300 ppm.

Group IV: Received a supplementary ration of ½-lb. groundnut cake per head per day between the 24th May and November 1957.

Methods

Faecal samples weighing at least 2 ounces were collected from the rectum for helminthological examinations. In February faecal egg counts were made by a modification of the technique described by Whitlock and Gordon (1939), using a 3 gramme faecal sample, 42 ml. of flotation fluid and a two cell McMaster counting chamber. From May onwards faeces were examined by the method of Roberts and O'Sullivan (1950) which gives counts in multiples of 10 eggs per gramme of faeces.

When faecal samples were taken from animals in Groups I, III and IV (i.e., from May onwards) samples of 3 grammes of well mixed faeces from each individual were combined to produce a bulk sample for each group and this was cultured at room temperature (70° to 80°F.) by the method of Roberts and O'Sullivan (1950). The infective larvae recovered were differentiated, using the criteria adopted by Keith (1953). The percentages of the various larvae encountered were applied to the mean undifferentiated strongyle egg count of the group and this was accepted as an estimate of the differential egg counts of the group. Armour (1958) has shown that figures obtained by this bulking technique compare closely with mean differential larval counts computed from cultures made separately for individuals constituting the group.

At examination *post-mortem* the number of worms infesting the abomasum and small intestine was estimated by Taylor's technique (1934). Under field conditions it was impossible to deal with the bulky material of the large intestine and although *Oesophagostomum radiatum* were found in all carcases they were not counted.

After sieving, large worms (*Haemonchus* and *Bunostomum*) were picked out from the entire washings of the abomasum and small intestine and counted. The number of smaller worms (*Cooperia* and *Trichostrongylus*) was estimated by counting all recovered from a hundredth part of the washings.

Results

(*a*) *Helminth burdens during the dry season*:—During the preliminary investigation carried out in February none of eleven calves, evenly distributed through the age groups 3, 4, 5 and 6 months, which had spent all of their lives in the calf yard, showed strongyle eggs in the faeces. It has been observed that calves exposed to infective larvae acquire infestations at a much earlier age than this and it can be concluded that the Shika calves, which spent the greater part of their lives in the calf pens during the dry season, were not exposed to heavy challenge. It is known that infective larvae were available in the calf yard at some time during the period July 1956 to February 1957 since two of four older unweaned animals, born during June 1956 but kept under the same conditions as the eleven younger animals mentioned above, showed strongyle egg counts of 100 and 350 eggs per gramme of faeces respectively. The most likely explanation is that these individuals become infected during the rains of 1956.

In contrast, all of 18 animals aged 10 to 17 months when examined in February showed evidence of strongyle infestation. The mean count in this group was 361 eggs per gramme of faeces with a range of 50 to 2,050.

(*b*) *Helminth burdens from March to May*:—Helminthological examinations made between the 14th and 17th May, on weaned calves which had been at pasture for various periods immediately prior to examination, provided information on the availability of infective larvae during the early rains. In one group of 22 calves aged 7 to 9 months, which had been at grass for 5 to 12 weeks prior to the mid-May observation, 9 showed no evidence of strongyle infestations. The mean egg counts of the positive animals was 38 eggs per gramme of faeces with a range of 10 to 60. The distribution of positive cases showed no bias in favour of the length of time the calves had been at pasture. For instance, of five animals which were turned out to pasture in the second half of March, four showed no strongyle eggs in the faeces when examined in May,

indicating that the infectivity of the grazing was low during March and April. March was completely dry and rainfall for April was 2.32 inches.

The position changed rapidly during May. A total of 14 calves turned out to grass on or before the 22nd April were found to be free of strongyle eggs at the mid-May observations. Seven of these which remained untreated with phenothiazine were available for examination during the 10th to 14th June and were, by then, all passing strongyle eggs. The mean count of these calves in June was 290 eggs per gramme of faeces with a range of 70 to 790 indicating that the availability of infective larvae increased considerably between the end of April and the latter part of May.

(*c*) *The Helminth Burdens during the Wet Season*: —

(i) *Haemonchus contortus*. The *Haemonchus* egg counts of the various groups during the wet season are shown in Figure 1.

All groups showed a progressive rise in *Haemonchus* egg counts during the first three months of heavy rainfall and until July the egg counts of Group I and III were almost identical. Thereafter, egg counts of Group I continued to rise and reached a peak in August, whereas those of Group III and IV declined and failed to regain the level maintained by the control group.

Group I, and to a lesser extent, Group IV, showed an interesting fall in *Haemonchus* egg counts between August and September during a period of very heavy rainfall. Almost a quarter of the total rainfall recorded during the whole wet season occurred between these observations and 11.02 inches fell in the 17 day period August 12th to 18th.

During 1958 an opportunity occurred to study the rise in *Haemonchus* egg counts during the early rains in a group of 10 calves all of which were at pasture on or before the end of April. June happened to be unusually hot and further information was obtained on the effect of slightly higher monthly mean temperatures than were recorded in May, 1957. The results are shown in Table II.

(ii) *Trichostrongylus Spp.* Larval differentiations confirmed by examination *post-mortem* revealed the presence of *Trichostrongylus axei* and *T. colubriformis* but the burdens were very small. The mean *Trichostrongylus* egg counts of the three groups combined was 2 eggs per gramme of faeces in May which rose to a peak of only 25 eggs recorded for September.

(iii) *Cooperia Spp.* A noticeable feature of the findings was the low *Cooperia* egg counts recorded for all groups. There were no marked differences between groups. The combined mean egg counts are shown in Figure 2.

During the first two months of heavy rains *Cooperia* egg counts rose somewhat more rapidly than those of *Haemonchus* and reached a peak in July. A sharp fall in egg counts occurred early in September following the heavy August rainfall and coincided with a similar decline in *Haemonchus* egg counts observed in Group I. It was followed by a secondary peak in October.

Examination *post-mortem* confirmed that the *Cooperia* species involved were *C. punctata* and *C. pectinata.*

The changes in faecal egg counts which occurred during the onset of the wet season of 1958 are shown in Table II.

(iv) *Oesophagostomum radiatum*: The seasonal pattern of *Oesophagostomum radiatum* egg output for the combined groups are also shown in Figure 2. Egg counts showed a gradual increase during the early month of the rains and by mid August the mean count was still only 41 eggs per gramme of faeces.

A decline occurred after the heavy August rainfall but this was followed by a sharp, progressive rise which continued until the observations were terminated at the end of October.

(v) *Bunostomum phlebotomum*: Egg counts remained at a very low level during June, July and August. Early in September the first significant rise was seen and a sharp peak occurred at the beginning of October followed by a decline similar to that shown by *Cooperia* species and by *Haemonchus* in Groups I and IV. The *Bunostomum* egg counts of the combined groups are shown in Figure 2.

The first losses occurred at the end of August when calf No. S.45 which showed the singularly high strongyle egg counts in July and August previously referred to, died. An examination *post-mortem* was not made.

Seven other animals died or were slaughtered *in extremis* between 16th September and 31st October.

While their removal undoubtedly affected, to some extent, the egg counts of the groups during the last two observations, they did not alter significantly the general trend of the rise or fall in the mean strongyle egg counts of the groups. Examination *post-mortem* were made on all and the results of worm counts are shown in Table III. The results confirmed the presence of the nematode species previously identified by larval differentiation and also showed that *Haemonchus* and *Bunostomum* burdens were generally high. They also showed that the low *Cooperia* and *Trichostrongylus* egg counts recorded in the course of faecal examinations were associated with low infestations of these species.

Discussion

It has been established by many workers that a certain degree of moisture is necessary for the development of the eggs of *Haemonchus, Trichostrongylus, Cooperia, Oesophagostomum* and *Bunostomum* to the infective larval stage. Monnig (1931) and Roberts and O'Sullivan (1950) considered that the infective larvae of these species may develop in pads of cattle faeces in the absence of rain but the latter authors state that some rainfall is necessary for the migration of infective larvae on to the surrounding grass where they become available to the host. It is thus unlikely that significant infestations can be acquired by the grazing animal during a prolonged drought provided there is not gross overcrowding or starvation involving grazing right up to the margin of the dung pads. Such conditions did not exist at Shika.

Rapid drying of dung pads during the Nigerian dry season appears to be a further deterrent to the development of infective larvae. Armour (1958—unpublished data) states that the moisture content of pads may fall from 80% to 25% within three days. At the end of the third day there remains a very small portion of moist faeces in the centre firmly sequestrated from the exterior by a hard, thick crust. In the absence of rain some larvae might conceivably reach the pasture through trampling of the dung or on the bodies of coprophagous beetles or ants but, thus exposed, their chances of

gaining access to the grazing animal must be slim indeed. This is supported by Sprent's failure (1946e) to recover infective larvae of *Haemonchus, Cooperia,* and *Oesophagostomum* from pastures at Vom, on the Bauchi Plateau, during December to March.

In view of the above, it seems that the failure to find strongyle eggs at Shika in February in the faeces of calves aged up to six months can be accounted for by the extreme dryness of the proceeding months reducing the availability of infective larvae. For the same reason it is likely that the older animals which showed up to 2,050 strongyle eggs per gramme of faeces at the February examinations acquired their infestations during, or shortly after, the wet season of 1956. It appears that animals infested during the previous rains play an important role in carrying infestations over from one wet season to the next. The failure in May to demonstrate eggs in the faeces of 9 of the 22 calves which by then had spent 5 to 12 weeks on pasture, subjected to 2.32 inches of rain in April, is a further indication of the low infectivity of dry season pastures. Further work is required to determine the effect, if any, of the high monthly mean maximum temperature (95.7°F.) recorded in April.

Referring now to the specific infestations, Veglia (1915) showed that the optimum temperature for the development of infective larvae from plots on which sheep faeces containing *Haemonchus contortus* eggs had been exposed to mean maximum temperatures of less than 65°F., irrespective of the amount of rainfall. Gordon (1948) states that mean maximum monthly temperatures of 63.9°F. or over are required for the development of haemonchosis in sheep in Australia. Dinnik and Dinnik (1958) working in the Kenya Highlands, where mean maximum monthly temperatures never drop below 64°F., found that diurnal fluctuation of air temperature is an additional factor governing the development of *H. contortus* larvae. They noted that infective larvae did not develop when diurnal fluctuations occurred between mean maxima of 73°F. and mean minima of 52°F. Though it does not appear to be important in connection with the present paper it should be noted that Silverman and Campbell (1959) state that *Haemonchus contortus* eggs can develop readily to the third larval stage at temperatures below 60°F. and their evidence suggests that the so-called "Dinaburg Line", i.e., a mean maximum temperature of 65°F. may be too high for universal application.

All of the above data apply to *Haemonchus contortus* in sheep faeces but it seems reasonable at present to postulate that the temperature required for the development of outbreaks in cattle probably do not differ greatly. On the other hand, a higher monthly rainfall is necessary for the development of haemonchosis in cattle than in sheep. Gordon (1948) gives a monthly rainfall of about two inches (associated with mean maximum monthly temperatures of at least 63.9°F.) as being necessary for the development of outbreaks in sheep, whereas Roberts (1950) states that at least 5 to 6 inches of rainfall per month appears necessary for the establishment of infestations heavy enough to cause outbreaks in cattle.

Applying these data to the Shika findings, Table 1 shows that monthly mean maximum temperatures remained well above 65°F. and diurnal variations did not exceed the limits which Dinnik found to inhibit the development of larvae. This situation applies equally well to the greater part of Nigeria. Furthermore, if Roberts' minimum rainfall requirements for the development of haemonchosis in cattle can be applied to Nigeria rising egg counts could have been expected at Shika during May

to September, inclusive. It was at this precise period that *Haemonchus* activity was detected in the experimental cattle.

At the higher temperature ranges Veglia (1915) showed that constant temperatures about 95°F. became increasingly unfavourable to the development of *Haemonchus* eggs and Shorb (1944) found that exposure of eggs to 98°F. for two days resulted in a very sharp fall in the number of larvae recovered when they were incubated subsequently under optimum conditions.

TABLE I.

Meteorological Records for Shika Stock Farm.

Month 1956	*Rainfall (inches)*	*Wet Days per month*	*Mean of Max. Temps. °F.*	*Mean of Min. Temps. °F.*	*Mean of Rel. Humidity at 4 p.m. (%)*
Sept.	11.88	—	84.8	65.7	64.2
Oct.	2.47	—	87.3	62.0	38.8
Nov.	Nil	Nil	90.3	59.8	20.6
Dec.	Nil	Nil	84.1	57.6	22.0
1957					
Jan.	Nil	Nil	85.5	54.8	13.8
Feb.	Nil	Nil	87.3	58.4	8.6
March	Nil	Nil	94.9	65.8	12.0
April	2.32	5	95.7	71.5	26.7
May	6.67	15	89.4	69.5	55.1
June	6.62	14	85.8	67.6	63.4
July	10.49	14	83.5	67.1	66.5
Aug.	13.32	19	83.5	67.2	64.8
Sept.	8.42	18	84.5	66.6	63.9
Oct.	2.64	6	87.3	66.4	54.4
Nov.	Nil	Nil	90.8	62.3	26.6

It thus appears that constant temperatures in the region of 98°F. either destroy the eggs or render them incapable of further development. Veglia (1915) found that the infective larval stages survive exposure to 108°F. for up to a month. Little attention appears to have been given to the effect of very high monthly mean maximum temperatures on the development of outbreaks of haemonchosis under field conditions. It is, therefore, important that the first noticeable rise in *Haemonchus* egg counts during 1957 were recorded in June indicating that the availability of infective larvae increased during May when the monthly mean temperature was 89.4°F., associated with 6.67 inches of rain. Table I shows that the first significant increase in pasture infectivity occurred in 1958 some time during May and June when monthly mean maximum temperatures were 91.7° respectively. It can be concluded that monthly mean maximum temperatures of, say, 91.7°F. did not inhibit the development of *Haemonchus* larvae. This is a significant figure since this temperature is not usually exceeded in Nigeria north of 9° latitude when rainfall exceeds 4 to 5 inches per month.

Applying these data to representative areas of Northern Nigeria it appears that rainfall (approximately 6 inches or more per month) and monthly mean maximum temperatures are suitable for the development of haemonchosis in an average year during May to September inclusive in the wetter parts and during two or three months from June or July to August or September in the drier areas.

Further work on the precise minimal rainfall requirements applicable to Northern Nigeria might extend the season slightly in some parts but in any event it is likely to be sufficiently short to enable haemonchosis to be controlled by relatively simple measures.

Figure 1 shows an interesting fall in the *Haemonchus* egg counts of Groups I and IV between September and October. After months of suitable climatic conditions it is reasonable to assume that the infectivity of the pastures was high during September. Mayhew (1942) has shown that *Haemonchus* infestations may persist in calves for up to 14 months and one would not have expected a sharp fall in egg counts so soon after the end of the heavy rains unless, by coincidence, the resistance of the calves had increased at this time. Similar sudden falls in the strongyle egg counts of both cattle and goats at the end of the rains have been observed locally on numerous occasions and it is apparently not necessarily related to the age of the infestation.

Sprent (1946 e) recorded a similar decrease in *Bunostomum phlebotomum* egg counts of Vom cattle at the end of the rains and showed that this was caused by a decrease in the egg laying capacity of the worms. He suggested that the coarse dry season fodder may have an inhibitory effect on egg laying. It would, therefore, be unwise to accept the October fall in *Haemonchus, Cooperia* and *Bunostomum* egg counts at Shika as reflecting a sharp decrease in worm burdens. Thus, while the season in which infestations are acquired probably terminates in October, it is known that clinical cases exhibiting low faecal egg counts persist into the dry season.

An interesting feature of the investigation was the low egg counts of *Trichostrongylus spp.* and the small *T. axei* and *T. colubriformis* burdens found at examination *post-mortem*. Rogers (1940) found that *Trichostrongylus* larvae are most active at 59°F. Roberts (1950) observed that *T. axei* were relatively scarce at Townsville where monthly mean maximum temperatures fluctuate between 75.5 and 87°F., though they are abundant in cooler parts of Australia. He suggests that larval activity decreases at monthly mean maximum temperatures exceeding 70° to 75°F. and that greatest activity probably occurs between 55° and 65°F. He also indicates that outbreaks of trichostrongylosis are unlikely to occur where rainfall is less than 3 inches per month. Accepting these criteria, it is seen that rainfall favoured the development of trichostrongylosis at Shika during May to September but that the high monthly mean maximum temperatures (83.5 to 89.4°F.) occurring at this time probably accounted for the almost complete absence of *Trichostrongylus axei* and for the scarcity of *T. colubriformis*. If this is correct, it would follow that outbreaks of *Trichostrongylosis* are unlikely to be common in Northern Nigeria since monthly mean maximum temperatures are usually 80°F. or more, and seldom fall below 75°F.

The precise climatic requirements of the other Strongyloid worms encountered at Shika are less clearly understood. Roberts *et al.* (1950) and Roberts (1951) considers that the temperature tolerance of *Cooperia punctata* is probably similar to that of *Haemonchus contortus* but that *Cooperia* require less rainfall for the build-up of infestations in cattle. A graph in his later paper clearly shows sharply rising *Cooperia* egg counts during a prolonged period when rainfall was in the region of two inches per month, associated with monthly mean maximum temperatures of 75 to 85°F. Recently, the temperature requirements of *Cooperia punctata* and *C. pectinata* were investigated at Vom and compared with those of *Haemonchus contortus* (Lee, unpublished data).

TABLE II.

Haemonchus and *Cooperia* faecal egg counts of 10 calves at Shika Stock Farm during the onset of the 1958 wet season.

HELMINTHOLOGICAL OBSERVATIONS				METEOROLOGICAL DATA		
Date of Examination	No. of animals positive	Mean egg counts. Eggs per gramme of faeces		Month	Mean Max. Temperature	Rainfall (inches)
		Haemonchus	*Cooperia*			
17th April	1	1	1	April	96.4	0.44
31st May	6	7	18	May	91.7	2.93
June		No Examinations made		June	93.7	6.33
9th July	10	81	212	—	—	—

TABLE III.

Worm burdens of calves at Shika Stock Farm, 1957.

					Number of adult worms recovered at post mortem			
Animal	Group	Date of death	*Haemonchus contortus*	*Bunostomum phlebotomum*	*Cooperia punctata and C. pectinata*	*Trichostrongylus axei*	*T. colubriformis*	*Oesophagostomum radiatum*
S.44	I	21.10.57	1,123	590	6,200	Nil	600	Positive
S.46	I	21.10.57	1,188	165	1,900	300	700	Positive
F.96	I	30.10.57	528	575	3,900	Nil	900	Positive
S.43	III	30.10.57	2,190	558	2,200	Nil	400	Positive
F.68	III	31.10.67	1,170	800	800	Nil	200	Positive
F.90	IV	16.9.57	2,190	55	1,800	400	400	Positive
S.34	IV	24.9.57	2,758	5	2,600	Nil	400	Positive

Mixed cultures containing eggs of *Haemonchus* and *Cooperia* yielded large numbers of infective larvae when incubated for ten to eleven days at constant temperatures of 77.0, 80.5, 86.0 and 92.5°F. and the ratio of *Haemonchus* to *Cooperia* larvae recovered at each of these temperatures was constant. When incubated at temperatures fluctuating between 64 and 68°F. there was a sharp decline in the number of infective larvae (of both species) recovered. At 98.6°F. practically no infective larvae were recovered.

It is thus clear that relatively high temperatures do not inhibit development of the infective larvae of *Cooperia punctata* and *C. pectinata* and in this respect their temperature requirements are similar to those of *Haemonchus contortus*.

The Shika findings confirm this since sharp rises in *Cooperia* egg counts occurred between May and June, 1957 and during May to June, 1958 following monthly mean maximum temperatures of 89.4 and 91.7 to 93.7°F., respectively. It can thus be concluded that the months which are now known to favour the acquisition of *Haemonchus* burdens should also be suitable for the establishment of *Cooperia* infestations. Further work, however, on the *minimal* rainfall requirements is necessary to define more precisely the maximum extent of the *Cooperia* season especially in those climatic areas of Northern Nigeria where moderate rainfall occurs at the beginning and the end of the wet season.

Although a sharp rise in *Cooperia* egg counts occurred between May and June at Shika it did not persist and the burdens subsequently experienced were lower than are commonly reported by workers in other countries. It appears that some factor other than air temperatures and moisture prevented the acquisition of heavy burdens.

The main feature of the *Oesophagostomum radiatum* egg counts was the gradual rise during the early months of the rains, when compared with the egg counts of *Haemonchus contortus* and *Cooperia spp.* This can be explained by the longer prepatent period of oesophagostomes rather than by a delay in the onset of suitable climatic conditions. Roberts (1950) suggests that temperature and rainfall requirements of *Haemonchus contortus* and *Oesophagostomum radiatum* are similar and it has been confirmed by Lee (unpublished data) that the infective larvae develop readily at constant temperatures from 77.0 to 92.5°F. One would therefore expect that oesophagostome eggs first found climatic conditions suitable for development to infective larvae in May. The prepatent period of *O. radiatum* is 37 to 41 days (Andrews and Maldonada, 1941) whereas the minimum prepatent period of *H. contortus* is 14 days (Mayhew, 1941) and of *Cooperia punctata* 11 days (Bailey, 1949). Consequently, calves first infected with *Oesophagostomum radiatum* early in May, would not show eggs in the faeces until Mid-June. On the other hand, animals infected on the same date with *Haemonchus contortus* and *Cooperia punctata* would have been passing a considerable number of eggs before the June observations were made and this earlier wave of egg production would add to the contamination of pastures and a more rapid build-up of these infestations would follow.

Bunostomum phlebotomum egg counts also showed a slow build-up during the early rains which was even more gradual than that of *Oesophagostomum radiatum.* This, too, was obviously due to the long prepatent period of the worm (56 days according to Sprent, 1946 d) and not to the early months of the rains being unsuitable for the development of the extra-host stages. In this, the curve of faecal egg counts at Shika agreed with Sprent's findings at Vom (1946 e) which showed that rainfall rather than air

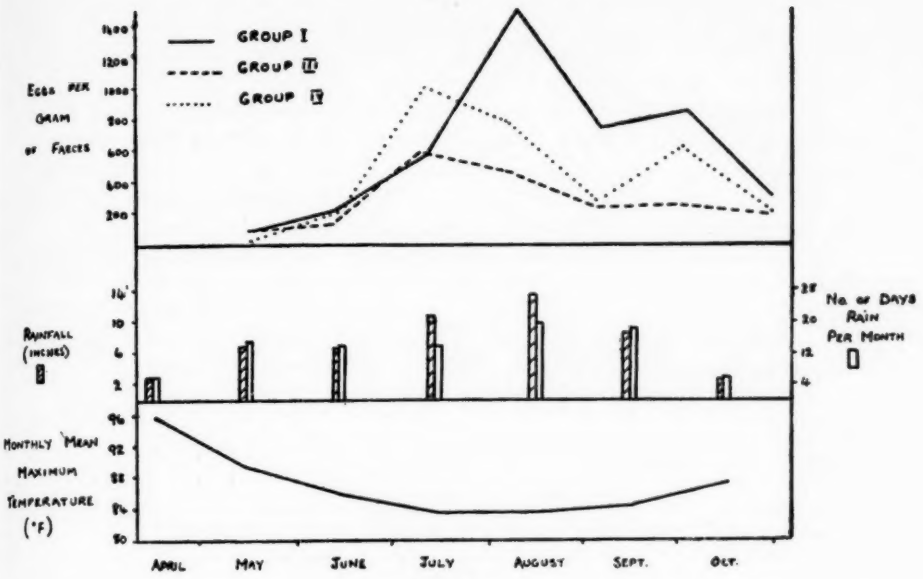

FIG. 1.

Haemonchus contortus. Faecal egg counts of cattle at Shika Stock Farm during the wet season of May to October, 1957.

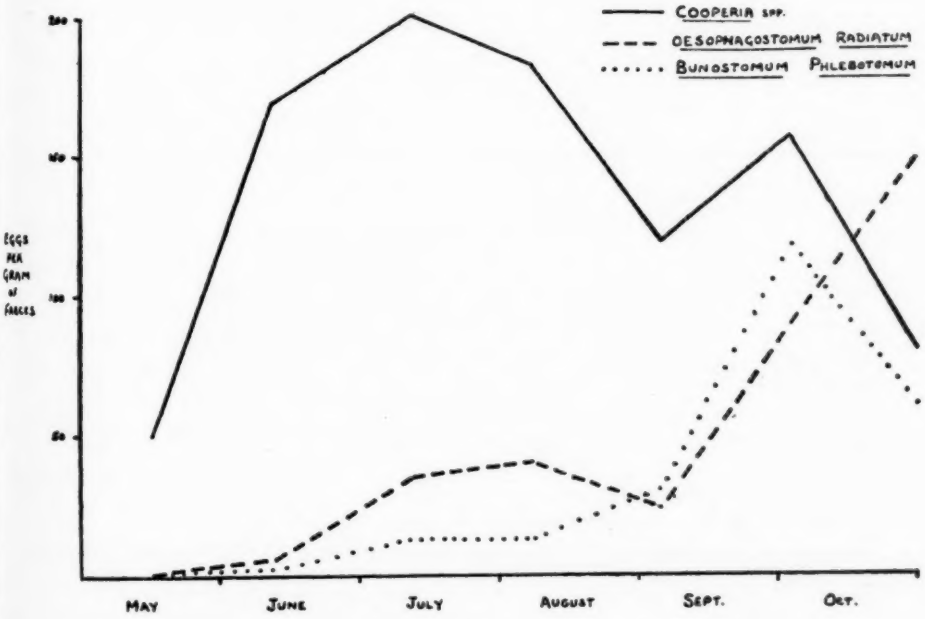

FIG. 2.

Faecal egg counts of *Cooperia* spp., *Oesophagostomum radiatum* and *Bunostomum phlebotomum* of cattle at Shika Stock Farm during the wet season of May to October, 1957.

temperatures was the important climatic factor controlling the seasonal appearance of hookworms in cattle. Thus, the first increase in egg counts which appeared in July implies that the first heavy rainfall of May initiated the successful development of the hookworm infective larvae.

Attention should be drawn to the sharp fall in *Haemonchus* egg counts which occurred in Groups I, and to a lesser extent in Groups III and IV, between August and September. A similar decline took place in *Cooperia,* and possibly in *Oesophagostomum,* egg counts. It is believed that this represents a manifestation of the "self-cure" phenomenon first described by Stoll (1929) and later investigated more fully by Stewart (1953) who showed that a sharp drop in egg counts can be induced by feeding large numbers of infective larvae. However, the larvae inducing the reaction may become established in the host and produce a secondary rise in egg counts. The fall in egg counts at Shika was recorded following a period of heavy rain when an increase in the population of infective larvae on pastures could be expected. Also, in the case of all species (except *Haemonchus* in Group III) the decline was followed by a marked rise.

The differences in the undifferentiated strongyle egg counts, which consisted mainly of *Haemonchus* eggs, of the animals on nutritive supplements (Groups III and IV) and the controls (Group I) were highly significant in August and September. This aspect of the investigation is being studied further and will not be discussed here.

Acknowledgments

Acknowledgments are due to the Ministry of Agriculture, Northern Region, Nigeria, for facilities and experimental animals used at Shika and to Mr. A. B. Rains, Senior Specialist Officer, and Mr. J. Simpson, Agricultural Superintendent, for valuable assistance in the management of the investigation. The authors are also indebted to Dr. J. I. Taylor, Director of Veterinary Research, for his interest and advice.

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REVIEWS

HANDBOOK DER TIERZUCHTUNG, Volume 2. Prof. Dr. I. Johansson. Berlin/Hamburg. Paul Parey.

The second volume of the Handbuch der Tierzüchtung is a very good book which presents a great quantity of organised information in a stimulating manner. In part, this is due to the declared intention of the editors " to synthesize results from 'pure' and applied research, relate it to practical experience and crystallize the information which they think is of primary importance in animal breeding work."

In spite of the fact that fourteen authors, mainly from Scandinavia, Germany and the United Kingdom, contribute, there is a considerable degree of uniformity in the presentation of the different chapters. This uniformity combined with an extensive use of headings and sub-headings, makes the book easy to refer to even by those whose knowledge of German is limited. Undoubtedly the careful thought which must have gone into the set-up of the book and the signs of strong editorial influence add greatly to the book's value. But why are there no English summaries after each chapter in a book which is intended for an international audience? As it is, the only English is in the Prefaces.

The volume has three main sections. The first section deals with the general basis of animal breeding in three chapters on the historical, current theoretical and statistical aspects of the subject. The second section deals, in ten chapters, with the inheritance of different characteristics in the economically important domestic animals, including poultry and fur-bearing animals. The third section discusses in three chapters, the application of genetic knowledge in the breeding programme of the horse, cow, sheep, goat, poultry and fur-bearing animals.

Obviously it is impossible to criticise in detail a book covering such a wide range of subjects and species. The only major criticism is one of regret that some things have been excluded, which considering how massive the book is already, may be rather unfair. Considerable detail is given of the inheritance of simple characteristics (e.g. colour of the coat and anatomical deformities). Similarly the economically important but physiologically very complex functions, such as milk production, are dealt with extensively. There is, however, little systematic discussion of the genetic aspect of variations in the physiological activity of individual organs and systems, a knowledge of which must surely be a base for a scientific study of the more complex, economically important functions.

The paper, printing and binding are of very good quality, completely in keeping with the high cost of the book.

CURRENT VIRUS RESEARCH (1959). *Brit. med. Bull. 15* No. 3.

Dr. C. H. Andrewes was the Chairman of a Committee of the British Council which planned this Bulletin and he is its scientific editor. This volume takes over the story of progress in virology where " Viruses in Medicine " (*Brit. med. Bull. 9.* No. 3) left off in 1953.

There are 18 specialists, all of whom are leaders in virology and between them they have contributed 15 papers on techniques and methods in virus research, discoveries of new viruses and on genetic, biochemical and epidemiological aspects of the subject. There is, at the moment, less need to write on smallpox, mumps, hepatitis and psittacosis but there is plenty to report about recent work on adenoviruses, measles, varicella and trachoma.

In addition to this there are accounts of the relationship between varicella and zoster, the present position of the enteroviruses, the immunisation against poliomyelitis, influenza and its complications, arthropod-borne viruses and myxomatosis.

Five or six chapters are concerned with new techniques, new conceptions and

fundamental advances, all of which affect the advances made on specific virus infections. A study of virus genetics may clarify some host-virus interactions. There are interactions between viruses themselves and the power of one virus to interfere with the development of another may be mediated by a substance, probably a protein, called interferon.

Trachoma is almost never seen in Britain but it is a widespread serious disease. The virus may be cultivated in series and in quantity and these and other advances should aid a fuller enquiry into the epidemiology of this and allied diseases. Myxomatosis is providing an example of evolutionary changes in a generalised virus infection under natural conditions. This virus behaves as a well-adjusted parasite in rabbits in Brazil where the upset to the host animal is negligible. In the European rabbit the disease is dramatic in its manifestations and spread; the course of events in Australia, Europe and America is discussed and compared and is an interesting story. The accounts given of the other diseases and of the general advances make equally fascinating and instructive reading.

THE CALF. ITS MANAGEMENT, FEEDING AND HEALTH (1959). By J. H. B. Roy. 2nd Edit. 126 pages. 10 plates. London. Farmer & Stockbreeder Pub. Ltd. 9/6.

This is the second edition; the first was published in 1955 and aimed at providing the farmer or student with a comprehensive survey of the various methods of calf rearing. An attempt has been made, in the second edition, to cover some of the recent advances made in the feeding, nutrition and physiology of the calf. A bibliography containing nearly 200 references is included in the hope that this will be of value to the more specialised student.

The book has two parts. Part 1 covers management and feeding and includes sections on calving and calving troubles, on housing and on dehorning and other routine operations. Part 1 forms the greater part of the book and is a good general and easily written account of the management and feeding of calves. Brief references are made to their nutrient requirements and this is followed by the feeding methods which may be employed for calves up to six months of age. Part 2 deals with calf diseases and takes up about one fifth only of the book. It should however be useful for farmers and agricultural students; a working knowledge of the causes and symptoms of calf diseases may help in their prevention and encourage stock owners to obtain veterinary advice with the least possible delay. It is a useful book with plenty of data on weights of calves, nutrient allowances, feeding mixtures, houses for the animals, modes of identification and the licensing of bulls.

ANIMAL HEALTH YEAR BOOK 1958. F.A.O. publication 1959. H.M.S.O. 10/-.

The annual world livestock disease report contained in this Year-book is the third to be issued. The countries which number well over 100 are listed in alphabetical order and the diseases are arranged in 17 tables; in all this is about 170 pages. It is possible by the use of code numbers to obtain information about the incidence of many diseases, the animal species affected and the methods of control adopted in all the countries of the world. All the information is given in English, in French and in Spanish.

As an example, we can learn that glanders, although eliminated from most countries of the world, is widespread in Turkey. Its incidence in horses and other equidae is low in France, Roumania, Italy, Jordan and Iraq. It is still present but reduced in occurrence in India, Burma and Mexico. Similar information, including the efforts made for control purposes, can be obtained about conditions varying from mange and helminth infestations to protozoal, bacterial, mycological and virus infections. There are also data concerning deficiency diseases and those of doubtful aetiology.

Short articles and comments are written on the global position and on the major changes in the livestock diseases position in 1958 compared with 1957. For example foot and mouth disease were less troublesome in Europe and there was an improvement in the rinderpest position in the Far East. Blue tongue has been reported in Idaho, U.S.A., and lumpy skin disease is now one of the important diseases of cattle in S. Africa. The special articles deal with the eradication of bovine tuberculosis, the Pan American Zoonoses Centre and its work, especially that concerned with foot and mouth disease at Rio de Janeiro.

An index, containing all the terms used in the tables for the different diseases, completes a valuable survey of the animal diseases position throughout the world.

THE HANNAH DAIRY RESEARCH INSTITUTE, KIRKHILL, AYR. REPORT (1959).

This report covers a period of three years ending 31st March, 1959. It is a pleasing booklet of just over 50 pages and gives a list of the members of Council and of Staff. Annual or triennial reports for the period 1929 to 1956 are also available.

The Institute is now 30 years old and has been responsible for valuable work in the production of home-grown feeding stuffs and on the energy metabolism of ruminants, special attention having been paid to the ability of different feeding stuffs to meet the energy requirements for maintenance and for milk production. Problems associated with climate, mastitis, milk production and the products manufactured from milk have also been attacked.

There are seven departments and today they continue their studies on some of the enzymes and vitamins in milk, the energy metabolism of ruminants, the association between a vitamin E deficiency and muscular disease, mastitis, the bacteriology of milk and the composition of milk. The Institute farm is of 134 acres and use is made of it for the determination of methods whereby the milk yield per cow and per acre can be maintained at a high level and if possible increased. The chemical composition of grass is also examined with this in view and observations are made on the physiological responses of cattle to climatic stress; the ultimate object of this latter project is the improvement of cattle productivity in hot countries.

The report concludes with an extensive list of the publications of the staff during the period March 1956 to March 1959.

FOURTH INTERNATIONAL CONGRESS OF BIOCHEMISTRY. Volume 5—Biochemistry of Antibiotics. Editors K. H. Spitzy and H. Brunner. 1959. London. Pergamon Press. 239 pp. + xii. 68/-.

The Fourth International Congress of Biochemistry was held in Vienna in September 1958 and the proceedings are published in 15 volumes. Volume 5 is the symposium on the biochemistry of antibiotics and there is an imposing list of authors from the United Kingdom, Europe, the U.S.S.R. and the U.S.A. Most of the articles are written in English and with their extensive bibliographies should have a wide appeal. They concern themselves with the classification of some antibiotic-producing micro-organisms, with the natural substances such as the coumarins and phenolic acids which influence germination in plant life, and with the structural patterns of many antibiotics. The latter may indicate the origin and relationships of antibiotics to each other. The metabolic alterations occurring in antibiotics, resistant micro-organisms, and the modification of their cell structure are also related.

The biochemistry of growth and multiplication is a common theme of study today; a knowledge of the mechanisms of the inhibition of microbial growth by antibiotics may shed some light on the main theme. Antibiotics may have a wider use than at present envisaged; the chemical substances which selectively inhibit the growth of mutants of micro-organisms might possibly acquire importance in the treatment of malignant growth. Furthermore it may be that antibiotics could be used for food preservation without harm to the consumer.

The symposium is of topical importance to biochemists and to all who use or contemplate using antibiotics for whatever purpose.

NEWS

ANIMAL HEALTH TRUST

Her Majesty the Queen has graciously consented to become Patron of the Animal Health Trust.

This was announced by the Duke of Devonshire, Hon. Treasurer of the Trust, at the Annual Meeting of Trustees and Council in London, when he took the chair in place of the President, the Duke of Norfolk, who is indisposed.

It was also announced at the Meeting that the Trust has decided to commemorate this great landmark in its history by erecting a new surgical unit at the Equine Research Station, Newmarket, at a cost of about £30,000.

The Animal Health Trust was founded by Dr. W. R. Wooldridge, F.R.C.V.S., in 1942 for the purpose of improving the general health standards of all types of domesticated animals, and it approaches the task in two ways. First by means of scientific investigation of the many disease problems; secondly by financial aid to stimulate the flow of graduates into the veterinary profession and by encouraging post graduate studies in all aspects.

Four research centres have been established by the Trust.

Her Majesty has shown keen interest in the work of the Animal Health Trust and has made informal visits of inspection to the Equine Research Station at Newmarket on two occasions.

NOTICES

BED-HEATER FOR ANIMALS

Attention is drawn by Gazelle Styles Ltd., makers of the ' Warmakennel ' heated dog bed, to the veterinary use of this product.

A thin, flat unit covered in waterproof Hydex, the ' Warmakennel ' is primarily for dogs, but is being used with success in zoos for all kinds of small animals. It has been found of value by Veterinary Surgeons in post-operative care, rheumatic illnesses and for treatment for shock . . . in fact, in all cases where controlled warmth is desirable.

The " Warmakennel " operates off a transformer that converts mains electricity to a safe 12 volts. Nevertheless, it is heavily insulated for complete safety. The Hydex cover is completely waterproof, non-absorbent, rot-proof and has very good abrasion resistance. The pad is simply placed under the animal's normal bedding and provides a pre-set heat just like the warmth of another animal. It is claimed that since it heats from *underneath,* it does not create a stuffy atmosphere like other forms of heating.

Particulars can be obtained from Gazelle Styles Ltd., 40 St. Mary Street, Bridgwater, Somerset.

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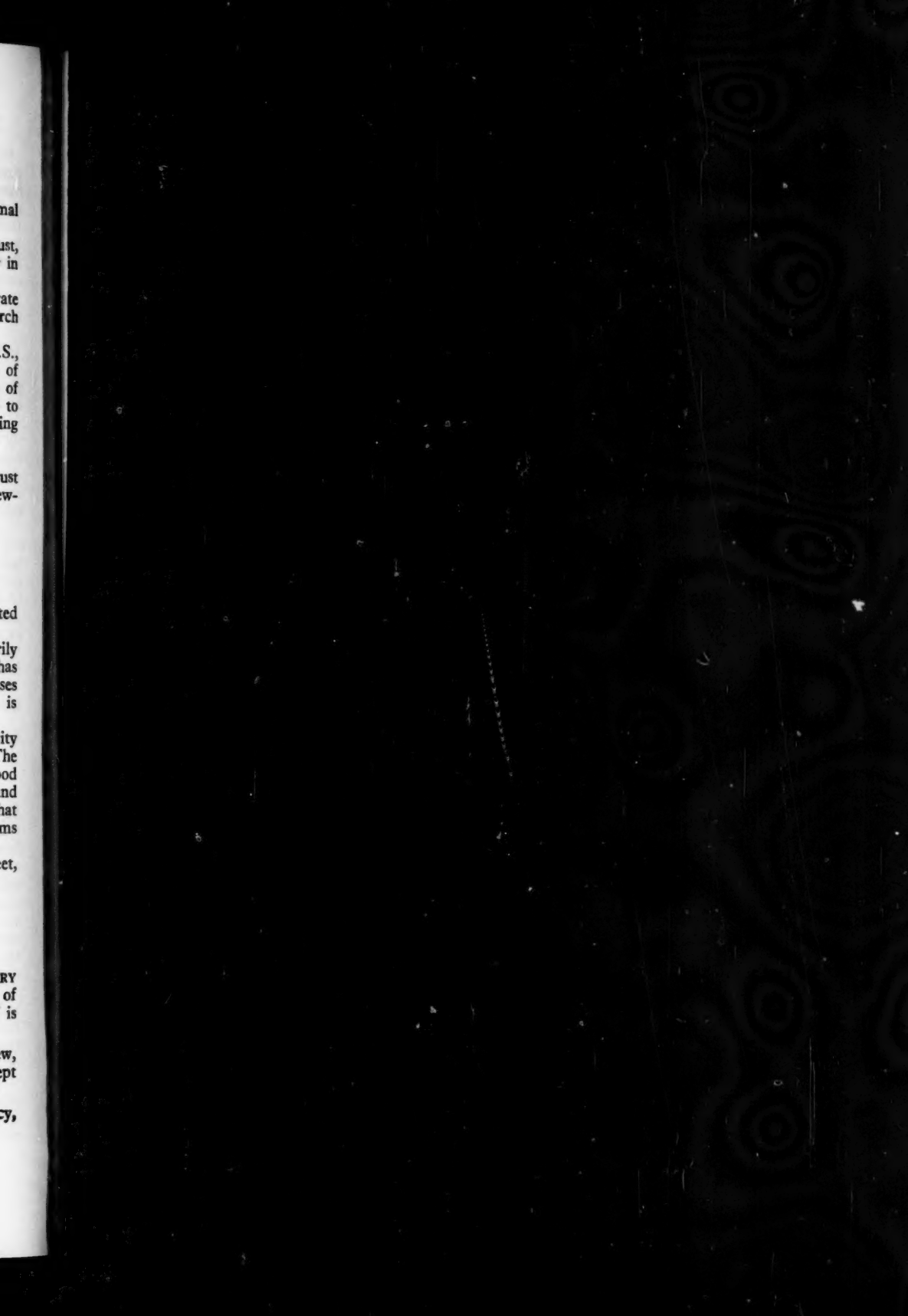
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